Materials & Methods

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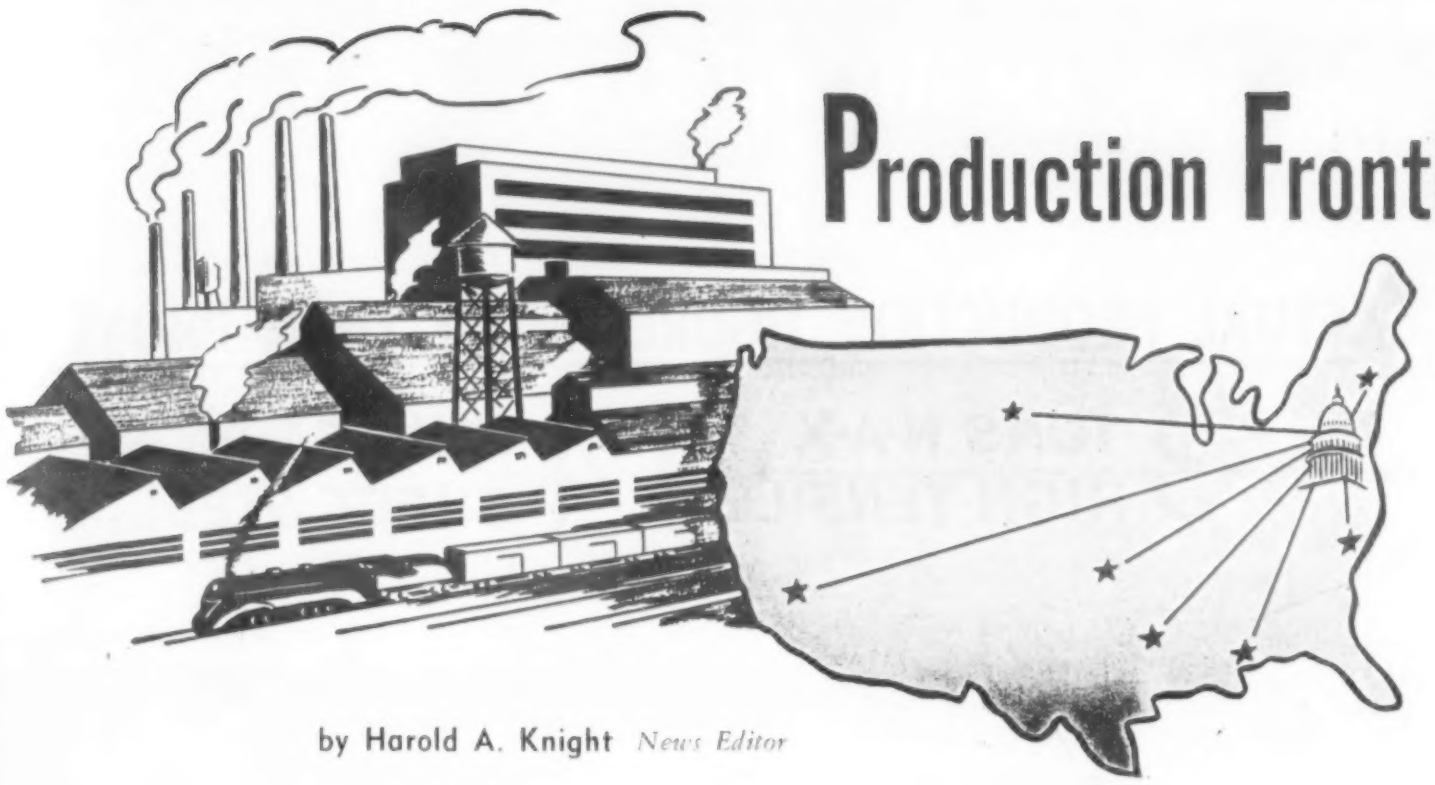

Production Frontiers

by Harold A. Knight *News Editor*

United States More Conscious of Foreign Problems

Now that economics, politics and labor-management relations are functioning a bit more smoothly in this country we have more time and energy to pay attention to world affairs—and surely one can't close one's eyes to them, what with Greece about to be abandoned by the British, the Palestine question begging for our participation, and aid to Turkey.

It becomes more evident that we taxpayers have got to shoulder heavier burdens abroad. However, there is a fine dividing line. There is some danger that we will overdo our help, making foreigners less self-reliant. There are limits, too, to the ability of the great United States to underwrite the entire world.

The inherent weakness of the British comes upon us as a shock. "The low productivity in Great Britain is a direct result of obdurate restrictive practices of British trade unions which have blocked introduction of modern machines and techniques for the past 50 years," writes Carl C. Harrington, editor, *Mill & Factory,* in the January issue. "Due to obsolescence of British industry the American miner digs six times as much coal as the British miner; the American pottery worker produces three times as many dishes; the textile worker two to nine times. Various crafts have jealously guarded their moth-eaten rights to perform certain jobs in long-outmoded ways.

"A no more dramatic object lesson could be given to American industry and labor as a warning against the dangers of featherbedding and other artificial restrictions on productivity," concludes Mr. Harrington.

Let's Look Around at Home

Here is a company to whom one should doff his hat in compliment to its efforts to prevent inflation. The Cooper-Bessemer Corp. has established a new "hold-the-line" price policy. They openly state their intent to hold the line, both as to sales of their Diesels, gas engines and compressors, and as to their own purchases of component materials and parts. International Harvester has gone a step farther, announcing reductions in farm machinery to save customers $20,000,000 yearly.

And here is an idea gleaned from Paul Wooton, famous Washington correspondent. "This certainly is the day of small business. The little man is in a stronger position today than at any time in history. Small concerns have relatively larger assets than big ones—profits higher, sales greater. Their total assets are 150% greater than in 1940, but only 55% for big business. By far the larger percentage of buying of plant and equipment has come from small durable goods concerns, buying relatively three times as much as large concerns. A one-man concern has no labor trouble."

Dun & Bradstreet, Inc., make the observation that for the first time in the history of American business, manufacturing failures outnumbered wholesaling and retailing failures in 1946, attributed to reconversion difficulties.

The National Industrial Conference Board contributes the following idea. Though profits in manufacturing were at peak levels in *current* dollars last year, they fell below corresponding totals for 1941 and 1943 in terms of dollars of *constant* purchasing power, but they were 54% higher than in 1939. These compilations are based on buying power of the dollar.

Universe in One Easy Lesson

"Backgrounds of the Atomic Age" is an intensely interesting piece by Dr. F. Scandone, professor of physics,

THE NEW ARITHMETIC IN STEEL

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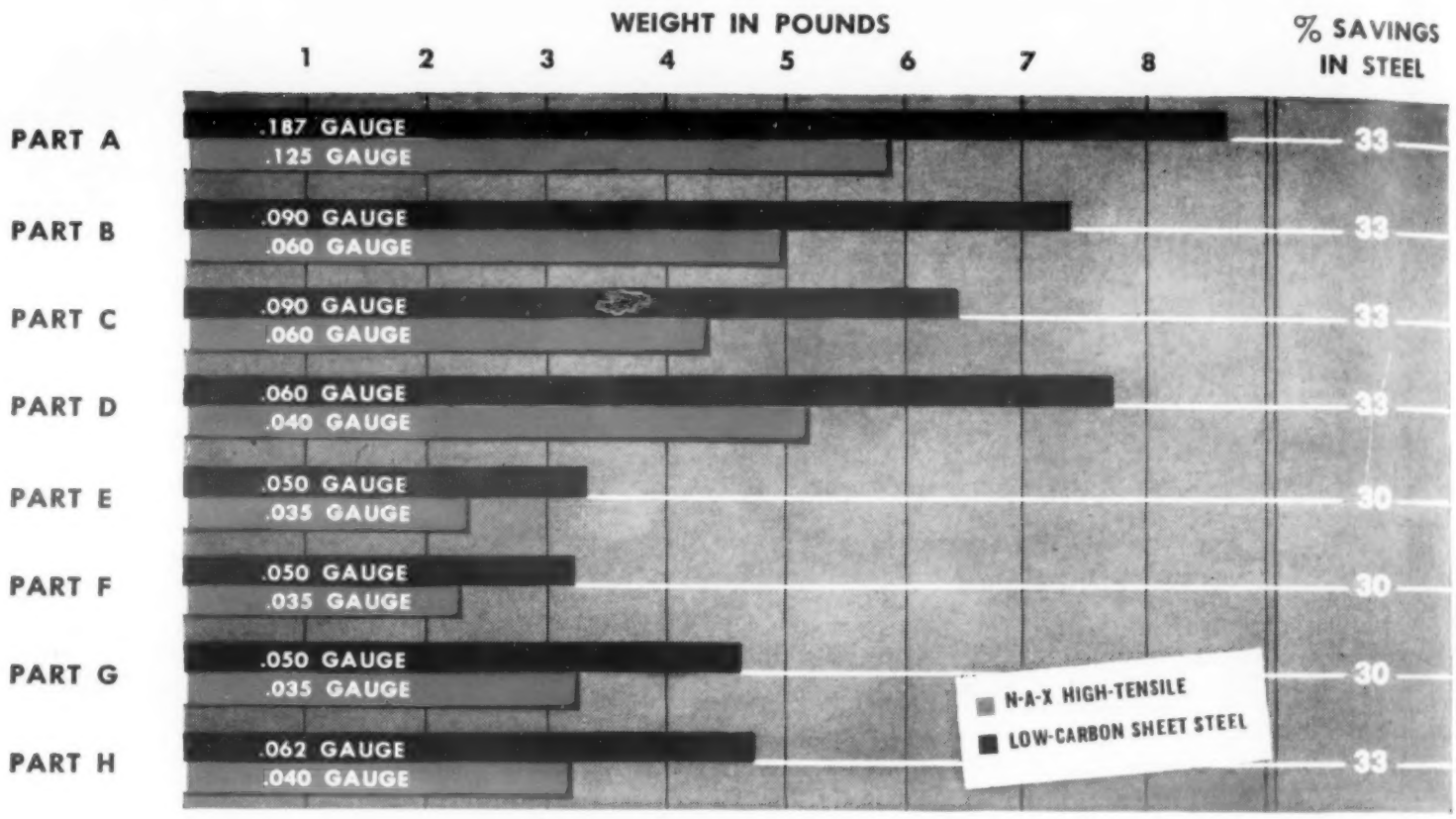

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University of Florence, published in the *Sperryscope,* Sperry Corp. It is presumptuous to try to digest this 8-page treatise in a few lines, but perhaps it will inspire the reader to investigate further.

About 2500 years ago Democritus conceived the idea of the atom. Thus, atoms very near to one another and strongly bound together constituted rock; atoms farther apart and able to slide over one another constituted liquids; those scattered widely apart and moving swiftly constituted air. The world of Democritus is colorless, scentless, silent and lifeless.

Galileo explained heat as due to the disorderly and increasing motion of the "indivisibles." In the 18th century Lavoisier propounded the fundamental law that nothing is created and nothing destroyed in nature. All transformation is merely exchange of atoms which remain eternal and unalterable.

The Russian chemist, Mendeleev, noted that by arranging known chemical elements in the ascending order of their weight, all properties followed a definite "rhythm," or repeated themselves after a certain number of elements. Gaps denoted existence of unknowns — several of which were discovered later. There are 92 "simple bodies" in all, the whole world being built with 92 different types of atoms.

Hydrogen has the "atomic number" of 1; helium 2; lithium 3, and up to 92 for uranium. The weight of all atoms is expressed in multiples of the hydrogen weight. Thus, lithium is 7, since a lithium atom weighs seven times as much as the hydrogen atom. As to atom size—a hundred million atoms aligned would measure an inch.

The atom, first thought indivisible, was found to contain another "particle" when electricity theorists studied it, this particle being called the "electron." In metals, rushing electrons hit against atoms making them oscillate, hence conducting electric current. In insulating bodies electrons are so strongly bound in fixed positions that there is little movement.

Rutherford, in 1911, demonstrated that the atom is not a homogeneous, indivisible, unchangeable piece of matter, but is a structure similar to our solar system, only in miniature. In the center is a small, heavy particle called the nucleus. Electrons whirl in elliptical orbits like our planets. Every nucleus attracts a definite number of electrons—hydrogen 1, uranium 92. Under more modern theory only the nucleus was indivisible and is only 1/10,000 the size of atoms.

Now it is apparent that nuclei of heavy atoms, such as uranium, explode, liberating energy and causing an atom that is lighter, thus making the dream of old alchemists come true. Radium goes through a series of transmutations, the end product being lead. By 1934 it became evident that there are two types of heavy particles: One has an electric charge of contrary sign to the electron and called the proton; the other, no charge and called the neutron. Protons and neutrons attract each other to form a nucleus.

The nucleus of hydrogen consists of one proton only; helium, two protons and two neutrons; uranium, 92 protons and 146 neutrons. Thus, the newer theory is that the world is reduced to three types of fundamental particles: Protons, neutrons and electrons, differing from one another only in the amounts of mass and electrical charge they possess. We can add to or subtract from a nucleus one or more neutrons without noticing any change in the atom's properties. These new atoms differ only in weight and are called isotopes. An example is heavy water in which two heavy hydrogen atoms substitute for both hydrogen atoms in the H_2O molecule.

Important was the discovery of a light isotope of uranium with three neutrons less, or U 235. About this time it was found that nuclei always weigh somewhat less than they do in theory, the lack of mass being called the mass defect, indicating that when single particles associate to build up

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a nucleus some of the matter is annihilated. Then Einstein came along with the theory that matter is nothing but highly condensed energy—a certain amount of matter can be annihilated, radiating in space an enormous quantity of energy which propagates indefinitely at the tremendous speed of light. Conversely, radiant energy traveling through space can be stopped, congealing to create a material particle.

When a body irradiates energy it loses some of its mass, but the rest of the universe, absorbing the same energy, augments its mass by the same amount. The whole process is a "distance transmission of mass." Energy developed from the annihilation of one gram of matter is 25,000,000 kilowatt hours. We must give back to the nucleus the same amount of energy it lost if we want to split it back into its components. The heaviest and the lightest elements are the less stable. Such transmutations, taking place in the interior of the stars, explain the inexhaustible source of energy of heavenly bodies.

Enrico Fermi developed the method of hitting a nucleus with neutron bullets, thus manufacturing isotopes from almost all the elements. U 238 was bombarded and converted into U 239, which, being radioactive, converted itself into a new element, never before found in nature, with number of 93, named neptunium. This is also unstable and transmutes into 94, called plutonium. The last proved fissionable and apt to set up an energy-releasing chain reaction.

And from there — continue on, History, and be kind to mankind! We at last behold the "harmony" of the universe which the ancients symbolized as the "music of the spheres."

Chromium and the Black Men

Strange how many of our essential metals are mined by black men! Remember in our November, 1946, issue we described the mining of columbium in Nigeria to the music of drums and flutes, numerous bigamous wives and myriad offspring assisting? And in our July issue the mining of vanadium in the Peruvian Andes?

Perhaps it is the mystic magic, the voodooism, the mumbo jumbo, the evil eye, the abracadaba of these blacks that gives the valuable qualities to these metals.

Let's take another trip into darkest Africa, this time with the late C. W. Van Law, vice president, Rhodesian Vanadium Corp., and see how they mine chromium in Southern Rhodesia. Our trip has been outlined for us in *Vancoram Review,* Vanadium Corp. of America.

We step aboard a freighter at New York, destined for Cape Town, with two stops in Africa enroute. The freighter is a "beautiful vessel, fast, new and beautifully equipped—for freight." Passengers are an afterthought and eight of us are bunked together in a steel cubby-hole, originally for anti-aircraft gunners. Twenty-five days later we are in Cape Town, with no laundry facilities the entire trip.

Then a 1900 mile rail journey in a "sleeping car" as comfortable as a park bench. After 29 days, in Salisbury, capital of Southern Rhodesia, "modern and bright as fresh paint" (containing much chrome yellow?). Streets are broad, well-paved, completely arched by trees solidly covered with blue and crimson flowers.

Southern Rhodesia, the size of California, is a landlocked country in southeastern Africa. To the north and west there are only jungle or desert. The climate is tropical, the intense heat being mitigated by the 4000-ft. elevation. Nearly three-fourths of the native labor employed in the mines comes from further north. A kind white boss develops tremendous loyalty among the blacks. They follow him unquestioningly from one employment to another and constantly recruiting more relatives from back home.

Gold mining is the principal interest, followed in order by tobacco, coal, asbestos and chromium. Chrome ore is a mixture of the oxides of iron and chromium, with such impurities as silica, magnesia and alumina. It ranges from dark brown to black; is hard and lumpy, or soft and friable, Rhodesian ore tending to be the latter. Weight is 220 lb. per cu. ft.

The chrome deposits in the Dyke area are unique in their mode of occurence, like layers of icing in a gigantic layer cake which has been eroded down into the rolling hills of a long ridge, 35 miles north to south. These layers, 8 in. thick or less, are parallel to one another. The first mining consisted of "stripping" away the overlaying rock, then "barring" up the chrome layer by hand.

Subsequently, underground operations were begun by sinking incline shafts from the hillsides, following the dip of the chrome seam. From the shafts horizontal levels were driven. Mining resembles that in the parallel anthracite seams of Pennsylvania. Early transportation was by ox cart, but now by trucks, often 35 miles to the nearest railroad. Electric power has recently become available and ore is shipped, non-concentrated.

The product of each pair of black "boys" is racked up at the mouth of the adit for payment on a cubic measurement basis. The ore is lowered from the hillside into the valley by a pair of buckets, run from tightly stretched steel cables. The descending full bucket pulls up the empty one. The railroad takes the ore to the port of Beira whence it is transported to Niagara Falls, N. Y., where it is mixed with fuel reducers in the electric furnace. The product is ferrochromium.

So, the black men and their black ores give us steels that are hard, resist corrosion and are generally useful.

Long, Cold Winter

Dr. Zay Jeffries always makes good "copy" for the press—particularly the technical brethren—because of his fresh viewpoints, analytical qualities and imagination. As you turn this page, readers, to scan a group of predictions under heading of "Materials Outlook," we are reminded of a story told by Dr. Jeffries.

The American Army engineers were building the Alcan highway and many of the engineers were sidetracked from highway construction to cut wood for keeping warm during the coming winter. Finally, the boss of construction began to worry over the hit-and-miss cutting, quantitatively speaking, fearing they would get a surplus of wood and a scarcity in road construction.

So, somebody suggested they consult a local Indian chief who was noted for his accurate weather forecasting. So, bearing him a gift of an alarm clock, they asked him: "Chief, how long the winter?"

"Ve-r-r-r-r-y long."

"But chief, are you sure? And how do you know?"

"Signs!"

"What signs?"

"White man—he cut much wood —long, cold winter."

The MATERIALS OUTLOOK...

Metals Situation Generally

Perhaps as this is read, some or all of the major metals will have declined in price from recent highs—in the case of lead an all-time high. Apparently no class has been more against recent high metals prices than the producers themselves. A few have shown real reluctance to advance prices, as indicated by a 24-hr. delay by one producer of lead after all other producers had advanced and a week's delay by a large copper producer. The reluctance is by no means altruistic, as the metals men have learned by experience that "the higher the mountains, the deeper the valleys." After World War I copper touched 24c, only to be down to 5c a very few years later. Not only have metals prices been high, but out of line with one another. Thus, the normal lead-copper relationship is 1 to 2. With lead at 15c recently, copper then should sell at 30c instead of 21½c. Metal users, wait as long as you can before buying!

Sheet Steel Failing of Goal

Production of steel sheet and strip in 1946 was 14,000,000 tons, or 2,000,000 tons under 1941, which is just too bad, for it should have been that much in excess because of the naturally and permanently expanded demand. The goal for the end of 1947 has been 19,000,000 tons yearly, but alas—steel makers will be lucky to be turning out 17,000,000 tons yearly then. Steel makers find it difficult to get machinery and electrical apparatus. So, where you can substitute a more plentiful material, do so.

Lead Supply Should Improve

Lead, extremely tight as to supply, should be considerably more abundant by year end, by which time it is safe for you to plan to use more. American production in 1947 should be 450,000 tons, barring strikes, as against 330,000 tons last year. Australia is shipping lead here, an absent source in 1946. New deposits have been found in Africa, and there is a new lead smelter on that Continent. A Canadian producer is shipping more to us than anticipated. An Australian metal producer, formerly turning out copper only, is now producing lead. High prices around 15c have brought forth much scrap from hiding. More old-time American lead miners have drifted back to the mines. Even so, lead will scarcely be abundant. An unfavorable factor is the fact that inventories in hands of consumers are only one-third normal, compared with fully normal in case of copper. It will take considerable lead merely to "fill the pipeline."

Zinc Becomes More Plentiful

You already can get reasonable quantities of zinc and supplies will improve. Europe is producing the metal at a faster rate than anticipated, Belgium turning it out at the pace of 156,000 tons yearly, a good tonnage, even if less than pre-war. There is considerable zinc due to the fact that aluminum roofing has in many cases substituted for galvanized steel roofing because of the extreme shortage in sheet steel. The present price of 11c is tops, and one can buy cheaper zinc by waiting a few months.

Emphasis on Quality Metals

In many an instance when you try to buy carbon steel or common alloy steel your distributor will suggest substituting a more expensive material, such as stainless steel or aluminum, which are often relatively more plentiful than the cheaper materials. Weigh the situation, perhaps take a chance and buy some of the expensive substitutes. You may find that the better physicals and longer life justify the extra expense. Often you will find that you do not care to return to the cheaper materials. Considerable such substitution is now perforce going on.

High Scrap Aluminum Price Temporary

Some of you who have investigated the possibility of making components of aluminum castings found that prices of secondary ingot were considerably higher than when you previously investigated. What happened is that scrap dealers had been collecting secondary aluminum during 1946 and decided to hold it over until 1947, since sales in 1946 would have resulted in additional somewhat bloated profits on which to make income tax payments. Prices so far this year have already declined, with a complete drop from late 1946 peaks of 3c per lb. expected. In short, dealers are now releasing their hoards at declining prices.

Shift Away from Copper

Plan to use some substitute for copper where the substitute is actually "just as good." We've got to knuckle down as a nation to supplies of 100,000 tons monthly, whereas present and normal consumption is 130,000 tons. Even with our 4c duty suspended or abrogated, we could actually import only 20,000 tons monthly, largely from South America. This, plus our own 80,000 tons of production, means only 100,000 tons monthly to play with. Again, copper prices will become more reasonable when consumption is curtailed. South America will have 50,000 tons of exportable copper monthly but will send at least half of that to Europe to maintain goodwill of old customers.

Laminates for Auto Tops

Materials engineers, don't overlook the low-pressure laminates. We received these figures from an authority. Assume you are considering a special model automobile to run 10,000 units. Now as to its top. Costs, plus amortization of dies, will be $35 per unit for steel and $32 for the laminate. One reason laminates are not in greater demand is because engineers have had so little experience with them.

Cheaper Copper Beryllium Springs

When anything becomes cheaper that's news. So beryllium copper coil springs are news. Same old story with a new product—it becomes cheaper as mass production gets under way. Recent improvements in mandrel coiling equipment have more than offset increased material and labor costs. Look for this trend to continue.

EDITORIAL COMMENT

Plea for More Pig Iron

Apparently there is something radically wrong with our basic supply of ferrous materials, pig iron and scrap. The war has been ended nearly two years, yet these raw materials are as scarce and even more erratic in market behavior than during the war. In recent months, prices of both pig iron and scrap have been soaring, the freakish element being the higher selling prices of scrap than of pig iron. Throughout the war and since, the closer the finished item has been to the raw state, such as iron and steel castings, the scarcer. An increase in capacity is plainly indicated and—since scrap supply cannot be pulled up by its own bootstraps—an increase in pig iron making capacity is called for. In this department only can one voluntarily step up our ability to produce, and the sooner we build more blast furnaces—say 10 to 20 more modern stacks—the quicker will the iron and steel supply adjust itself.

In 1946 our capacity for pig iron production was 73.3% of our capacity for steel ingots, a slight improvement in ten years, since in 1936 this figure was 71.8%. Apparently the increase in percentage has not been rapid enough and probably should be raised to close to 80%.

The fact that there has been a series of crises in steel scrap supplies over the past five years accentuates the seriousness of the situation. During each campaign to "get out the scrap" more and more obsolete engineering items, such as steel bridges, were torn down until by now we have virtually scraped the bottom of the scrap barrel.

Oh, but many will say, this is an unusual situation. In a few months or years the country will be saturated with items made of steel, and construction of more blast furnaces would mean just that many more idle furnaces when depression comes. But will it be only a few months or years?

Remember that German, Japanese and some of our allies' steel industries were badly shattered during the war. More and more is the entire world depending on the United States steel supply. Again, more and more does it become our realization and responsibility to supply the world with its necessities.

And finally—in view of the constantly greater contamination of scrap we need more and more virgin iron to cut down the "residuals" in the final mixture in steel-making furnaces. Whether pig iron production is increased by building new furnaces or by using oxygen blast on existing furnaces, output must be boosted if we are going to meet our requirements for steel in the months and years ahead.

—H. A. K.

The Price of Materials

While most of the price news lately has been bad, there are a few bright rays breaking through to give us some hope. As pointed out in this issue, plastics prices should come down soon with increased plant capacity; steel makers are eliminating some of the extra charges. Should steel go lower or resist the pressure to advance through the higher wages that are coming, many industrialists will be tempted to reduce their prices. Some already have.

Continued actions of this sort will serve to deflate the over-inflated price structure and perhaps stave off or postpone indefinitely the well advertised recession, scheduled for late this or early next year.

—T. C. D.

Steel for the Building Field

For many years light gage steel has received rather unenthusiastic consideration as a structural material in the small building field. Although its possible advantages, such as lighter weight, ease of handling, and lower cost as compared to conventional materials, are generally known, a number of obstacles have discouraged its wide acceptance. Practically no design data have been available; there has been no standardization of structural shapes and members, and no standard materials specifications.

However, rapid progress is now being made to resolve these obstacles. In a recent talk before the New York Chapter of the Society for the Advancement of Management, Mr. Milton Male, an authority on the subject, pointed out three developments since 1939 which are promoting more extensive use of light gage steel in building construction.

First, two standard materials specifications on light gage stock have been established by the American Society for Testing Materials. Second, structural design data on light gage steel has been developed by the American Iron & Steel Institute. Thus, a much-needed sound and rational basis for structural design with light gage strip and sheet (below ¼-in. thick) has been provided. And third, the American Iron & Steel Institute has also designed a series of standard light structural shapes. Full information on these new shapes will be contained in a manual to be distributed in the near future, and it is very likely that the major steel companies will soon be producing them.

However, two important problems of a non-technical nature remain to be solved. One of these is the question of just which group of workmen are "eligible" to erect the steel work for small buildings. In general, it appears that regular construction workers can do the work satisfactorily, but the structural steel erectors' unions feel that this is an encroachment upon their domain; consequently, jurisdictional disputes are now prevalent.

The other problem is one of distribution or marketing. As yet, a comprehensive distribution system has not been devised that will make light structural steel products as readily available as conventional materials to builders. There have been a number of possible distribution plans advanced. One is to market through the regular building supplies channels; another is to set-up distributors for the exclusive handling of these steel products.

Thus, it appears that although most of the technical problems have now been solved, the maximum use of light gage steel in building construction depends on the solution of these non-technical matters. And, according to Mr. Male, this will probably take several more years.

—H. R. C.

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APRIL 1947

What's Happening with Plastics Prices and Supplies

by JOSEPH V. SHERMAN

BEFORE PLANNING TO MAKE that new industrial part or consumer item of plastics, the prospective manufacturer or designer will give considerable thought to the availability of the basic materials and their probable price trends, if he is to avoid many headaches and much lost time later on. A spokesman for the plastics industry even went so far recently as to suggest that prospective purchasers of new parts or devices postpone their introduction until a supply of necessary materials is assured.

Reasons for the present shortages of plastics materials are numerous and varied. Like other industries, the plastics industry has been affected by a series of difficulties in its sources of supply. Strikes in such basic lines of supply as the coal and steel industries, shortages of machinery and equipment, and other factors which have kept industry generally from going into high gear, have all left their mark on plastics. To top it all off, the demand for plastics has risen to unprecedented heights since the end of the war. Producers plan to spend between $125 million and $145 million, from early 1947 through 1948, to expand manufacturing facilities for plastics materials. But it is still uncertain whether or not the vast expansion now under way will take care of industry requirements.

The price trend of plastics materials over a period of years has been generally downward, thus improving their competitive position relative to other structural materials. The wide variety of raw materials from which plastics can be made, together with unlimited potential availability, gives every indication that, in time, problems now affecting supply will be fully solved and the downward price trend resumed.

Plastics are made from the same basic raw materials as are other products of the chemical industry. They utilize coal, limestone, petroleum, salt, cotton, wood, air, and water. However, conversion of these raw materials into chemicals suitable for industrial use requires elaborate plant and equipment and involves a great deal of processing. It is here that many bottlenecks in production have occurred.

In getting its basic chemicals, the plastics industry must compete with many others. Thus, it has to compete with synthetic rubber for styrene, with fertilizer for urea, with anti-freeze for methanol, and with paints for pigments. These are just a few of the cases where the supply of plastics materials is contingent in part upon factors outside the industry.

However, no generalizations will necessarily apply to the industry as a whole. There are about a dozen important types of plastics, each differing from the others in chemical composition and properties, as well as in availability and prices. Moreover, the situation regarding supplies and prices is subject to change without notice. The intelligent manufacturer or designer, who contemplates making new parts or products of plastics, will therefore first determine which material or materials will best do the job, and second, whether these materials will be available and at what prices. If possible, he should decide on one or two alternative materials, in case he has difficulty obtaining his first choice. But the possibilities of substituting one plastic for another are limited and in no case should important qualities desired in the end product be sacrificed through misapplications of plastics materials. Better that he wait until he can get the right material for the job.

Before discussing relative availability of the different materials, it may be well to point out that all plastics fall into two general groups—thermosetting and thermoplastic. Thermosetting materials set, or harden, when subjected to heat. They become infusible and insoluble, and further application of heat will not soften them. Thermoplastic materials, on the other hand, soften upon application of heat and

Although the plastics supply picture is improving, plant and basic material shortages will continue to restrict quantities of some important resins.

harden upon cooling. They can be reshaped again by alternate heating and cooling. The two groups are as different as concrete and paraffin. In general, most thermoplastics soften at temperatures above 160 F, although softening points of some of the newer types are considerably higher than this.

Thermosetting plastics include three important groups—phenolics, ureas, and melamines. These are made by combining phenol, urea, or melamine with formaldehyde. Thermoplastic materials include those based on cellulose nitrate, cellulose acetate (including the butyrate), ethyl cellulose, the vinyl compounds, the acrylics, polystyrene, polyethylene, and nylon. It is obvious from the names of these plastics that they differ considerably in their chemical origin and that the availability of each important class must be considered separately.

The Supply Situation

The following comment on supply situations of the different plastics is taken from recent reports issued by the U. S. Department of Commerce.

Phenolic Resins. Acute shortages of basic materials and labor-management difficulties have affected production of phenolic molding and laminating materials. Phenol was in short supply even prior to the strikes in the coal and steel industries in 1946. The supply position of phenol is now exceedingly tight, with production heavily contracted for delivery during 1947. It is estimated that the shortage will not be eliminated in less than 6 to 12 months.

Urea and Melamine Molding Powders. Availability of supplies of urea and formaldehyde has been a limiting factor in production, although new production units for these chemicals should improve the supply situation. Producers of urea and melamine molding powders have been operating at near capacity, and the current ratio of demand to supply is about 4 to 1. Substantial increases in production were achieved in 1946, and further expansion in facilities is under way for completion late in 1947.

Cellulose Esters. Production of these plastics in the forms of sheets, rods, tubes, and films during 1946 was at a rate of 18% above 1945. However, demand was greatly in excess of supply, particularly for continuous sheeting. Output has been increased and consumers anticipate better availability of film through the use of additional facilities to be completed in 1947.

Production of cellulose acetate molding powders increased from 61 million lb. in 1945 to 83 million lb. in 1946. The ratio of demand to supply for the molding powder was about 3 to 1, and demand for flaked material was estimated to be in excess of supply by a ratio of 2 to 1, in the latter part of 1946. Substantial increases in productive capacity for other special types of cellulosic plastics have been completed and the industry has been operating at approximately 50% over the 1945 rate.

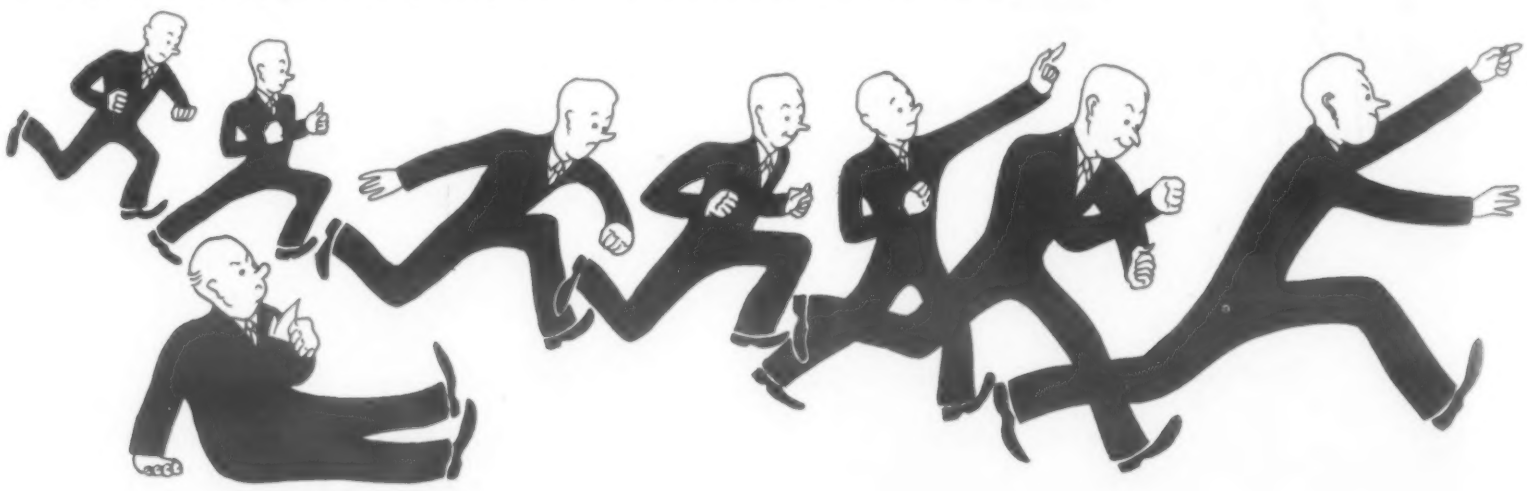
Nitrocellulose. Availability of nitrocellulose is about equal to demand. Production rate at the end of 1946 was about 20% greater than the 1945 output, which amounted to 15 million lb.

Vinyl Resins. Producers of these materials have been operating at high production rates. The ratio of demand to supply for polyvinyl chloride and copolymer resins and for vinylidene chloride is in each case about 3 to 1. During the latter part of 1945, full productive capacity for these resins was not utilized because of reconversion problems in plants of producers and consumers. The end use pattern for the vinyls changed extensively with the shift from war to civilian production. The production rate in 1946 averaged more than 50% above that for the last five months of 1945.

Polystyrene Resins. Production of polystyrene resins has increased enormously during the past few years. Annual production rate based on the last four months of 1945 was 24 million lb., while output in 1946 was 67 million lb. The demand-to-supply ratio in the latter part of the year was estimated at 2 to 1. However, increasing availability of polystyrene was indicated and the rate of production at the beginning of 1947 was estimated to be four times the average rate during 1945.

Miscellaneous Plastics. Production of acrylic, nylon, polyethylene, and other miscellaneous plastics in 1946 was well in excess of 1945 rates. A fourfold expansion has been possible for certain molding ma-

Although the supply picture is improving, there is still a mad scramble for some plastics.



terials, and substantial capacity has been brought into operation for other new materials.

Demand for laminating and industrial resins has been somewhat in excess of current supplies, although producers are operating at rates considerably above 1945 production. In some cases, operations have been increased by 100%. The same situation prevails for cast resins, particularly the phenolic type.

Production of synthetic resin adhesives, both phenolics and ureas, has been considerably in excess of 1945. Recent operations have been from 25 to 90% over the former period, with demand running at about 1½ times the supply. Some expansion in adhesive manufacturing capacity has been made, and additional facilities under way should further increase productive capacity.

In order to make a last-minute survey of the supply situation and appraise the future outlook, the writer recently interviewed representatives of six leading companies, which account for a major portion of total U. S. production of plastics materials.

Thermoplastics Supply Improves

A spokesman for one of the largest and best-diversified producers of plastics reported that the shortage of thermosetting materials is still very acute and will probably remain tight over the next few months, but that there has recently been some improvement in supply of thermoplastics. This company has sufficient plant capacity and manpower to produce 20% more phenolic materials in 1947 than in 1946, but it has enough phenol to make only 70% of last year's output. Supply of formaldehyde was declared to be sufficient for the amount of phenol available, but insufficient for total requirements. The situation in the ureas was said to be better than in the phenolics, but also to be tight, not only on account of the formaldehyde shortage, but also because of the amount of urea going into fertilizer.

A decline during the last few months in demand for "glamor items" was noted. This, in turn, has led to an increase in availability of certain materials, chiefly thermoplastics. Decline in demand for "glamor items" was attributed to misapplications of plastics during the war. Brightest spot in the entire plastics picture was said to be in polystyrene, in which vast increases in productive capacity are under way. Availability of polystyrene has shown definite improvement since last fall. Shortages of plasticizers are still hampering the use of thermoplastics, notably the vinyls and acetates. The general situation was expected to remain much the same for the rest of the year, although possibilities of sudden change were not excluded.

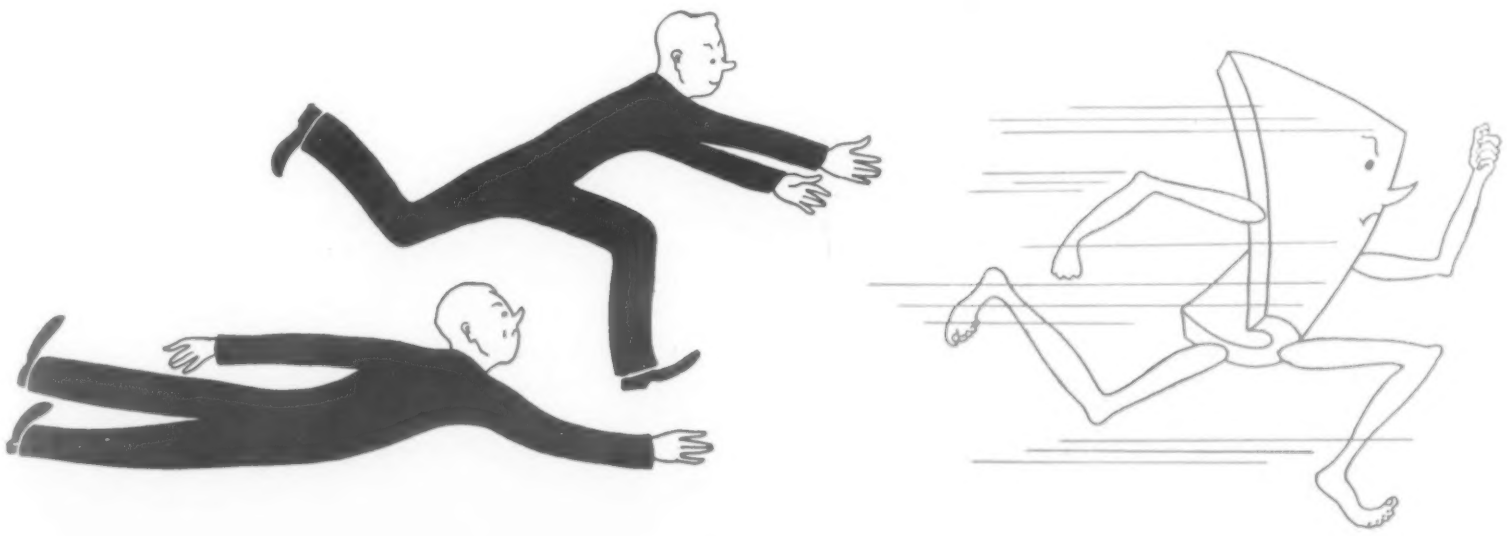
A representative of another large plastics producer with a well-rounded line of materials also said that the situation in the phenolics is very tight and that the bottleneck is in phenol. He added that polystyrene is now "out of the woods," and that his company recently took it off the allocation list. It is now the only plastic not on allocation by this company. A general decline in demand for thermoplastics was noted and a resultant improvement in the availability of these materials.

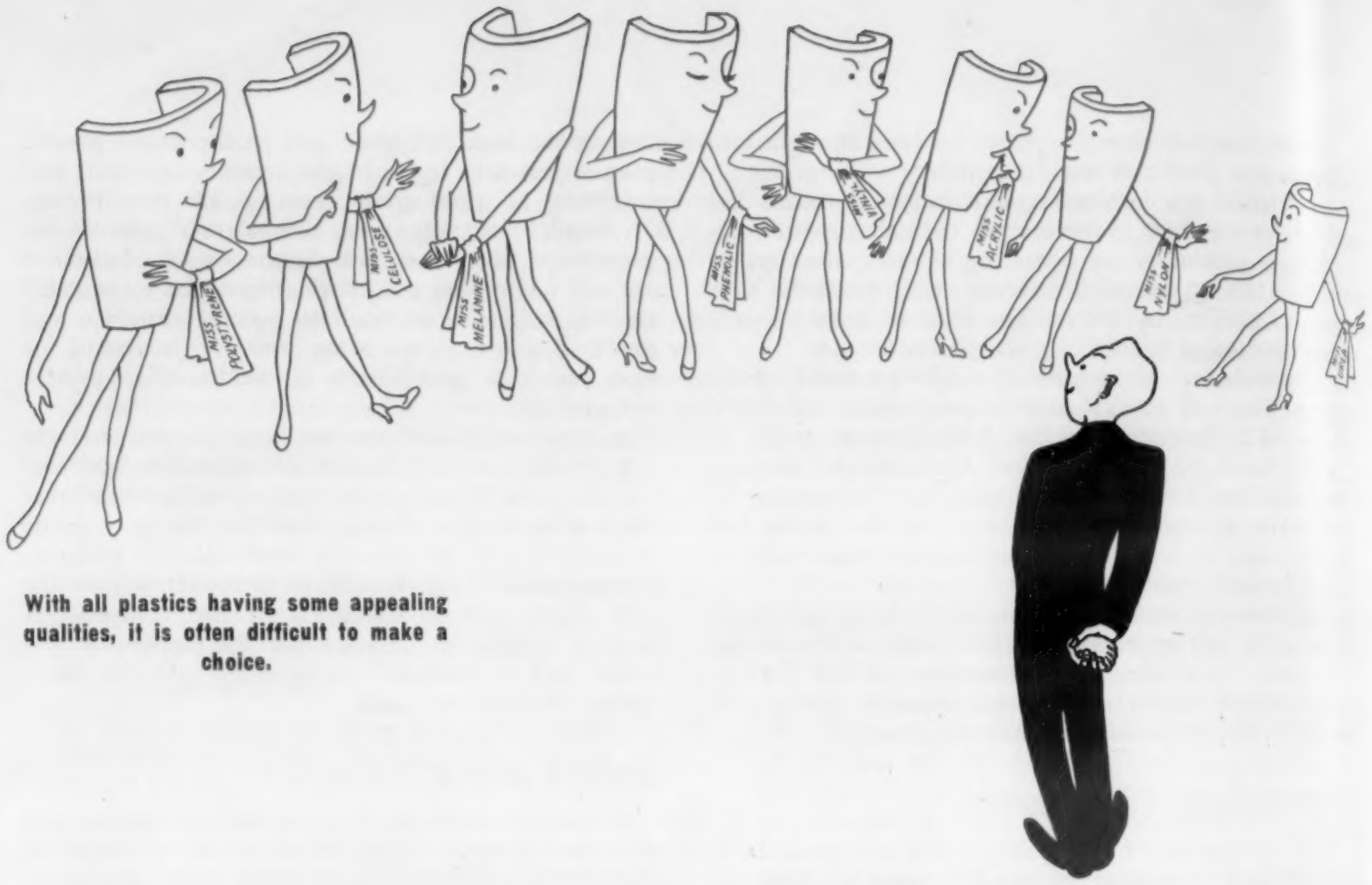
Shortages in Basic Supplies

A leading producer of ureas and melamines said that the shortage of formaldehyde continues unabated, and that this affects both of these types of plastics. No change was expected until the third or fourth quarter of this year, when increased supplies of formaldehyde may become available as a result of expansion in methanol productive capacity by a large producer. In addition, a shortage of urea was noted.

One of the largest manufacturers of cellulosic plastics reported an improvement in the supply situation of cellulose acetate molding powder, and pointed to substantial increases in productive capacity planned for this year. The opinion was expressed that enough acetate molding powder would be available to meet all essential needs. However, demand for acetate sheets, rods and tubes is running ahead of supply in the ratio of 3 or 4 to 1.

Recently, there has been some increase in prices of cellulosic materials, particularly in ethyl cellulose, which has risen sharply, but it is hoped that no further price increases will be necessary in the im-





With all plastics having some appealing qualities, it is often difficult to make a choice.

mediate future. Such would divert still more business to polystyrene, which has already gained considerably at the expense of cellulosic plastics.

One of the largest producers of polystyrene said that the supply outlook for this plastic is becoming much brighter. This company and others are expanding enormously their polystyrene productive capacity. Styrene has been going not only into molded plastics but also, more recently, into paints and surface coatings of various kinds. Productive capacity is also being expanded for another thermoplastic, vinylidene chloride, which, in the form of extruded filaments, is being used increasingly for making screening, upholstery, and various fabrics. However, a recent decline in demand for plastics was reported by this company.

This general decline in demand for thermoplastics was attributed by a spokesman for another company to the business recession and reduction in consumer purchasing power. He said that during the war period and immediately after there was much money in the hands of war workers and service men and women for the purchase of luxury items. After these wartime savings, bonuses and the like were spent, demand for luxury items began to taper off. One result has been that such plastics materials as the acrylics have become more available. Some of these materials, which were tight a few months ago, can now be purchased on short order. Also, some of the newer plastics materials, like polyethylene, are becoming available in substantial quantities and finding many new applications.

From the foregoing, it is apparent that the supply picture for the remainder of 1947 is brightest in the thermoplastic materials for which productive capacity is undergoing rapid expansion, and for which demand in certain cases has recently shown some slackening. The supply situation is most critical in the thermosetting materials in which there continues to be a serious shortage of basic chemicals used in their manufacture.

Most seriously affected by shortages are the phenolics. The phenolics are the oldest, most important, and cheapest of all the heat-resistant plastics, and have been termed the "work horse" of the industry. Despite the introduction of many new types of plastics in recent years, the phenolics are still by far the largest single group in commercial use. Their applications have been chiefly in such important industries as the electrical and radio, automotive, container, and others that supply essential goods. Molded phenolics are familiar everywhere in telephone handsets, electrical parts, and other items characterized by their black or brown color. Phenolic resins have also been widely used for bonding exterior types of plywood and in paints.

Second most important of the thermosetting materials are the ureas, which, although more expensive than the phenolics, have come into rapidly increasing use because of their wide color possibilities in molded parts. The melamines possess certain advantages over both the phenolics and ureas for special applications, but are more expensive and produced in only limited quantities.

Up until recent years, the cellulose family of plastics accounted for the great bulk of all thermoplastics used, but since the 1930's there has been a steady procession of new types, with the result that the cellulose materials have lost some of their former importance. Cellulose nitrate (celluloid), oldest of all plastics, has shown declining tendencies in recent years but is still used in substantial quantities. Because of its availability, it has been used in many cases where it should not be, and its flammability has been a serious drawback. Such misapplications have been largely responsible for bringing plastics generally into

Typical Prices of Plastics Molding Materials

Material	Price Per Lb.
Thermosetting	
Phenolic	$0.15
Urea	0.32
Melamine	0.50
Thermoplastic	
Polystyrene	0.25
Cellulose acetate	0.50
Vinyl	0.50
Polyethylene	0.55
Cellulose acetate butyrate	0.55
Ethyl cellulose	0.68
Acrylic	0.85
Nylon	1.60

disrepute, and the industry is anxious to avoid them. While there are many applications where cellulose nitrate is entirely satisfactory, there are others where cellulose acetate or other materials should be used.

Cellulose acetate molding materials have shown rapid growth in recent years to an all-time high in 1946. Nevertheless, there has been some displacement of cellulose acetate in certain applications by newer thermoplastic materials, particularly polystyrene. This is attributed in part to a widening spread between the prices of cellulose acetate and polystyrene. The latter has been reduced over a period of years to the point where it is the cheapest of all thermoplastic materials and sells at a price one-half that of the acetate.

Many authorities believe that over the longer term the greatest growth in plastics will occur in such materials as the vinyls, the acrylics, and polystyrene. This is predicated on the tremendous expansion in productive capacity that has taken place and will take place in these materials, the many new uses that are being developed, and the possibilities of substantial price reductions. For example, the annual capacity of styrene plants used in the synthetic rubber program is about 400 million lb., and increasing quantities of styrene should be available for making plastics. One company alone has recently announced an expansion program which will increase its productive capacity for making polystyrene to an annual 80 million lb.—more than total U. S. consumption in 1946. The price of polystyrene has shown a steady downward trend from 45c a lb. in the early part of 1942 to 25c, and it is expected to go lower.

Some of the newer plastics materials, such as polyethylene, nylon, and vinylidene chloride, are also expected to show rapid growth as their production attains larger volume and new uses are developed. These materials are still relatively young commercially.

The greatest gains in use of plastics over the next ten-year period should be scored by some of the newer materials. Markets and prices for the older plastics have been relatively well established, and, consequently, their opportunities for finding new uses or lower costs of production are relatively limited. The phenolics, for example, have been on the market many years and it is probable that they are already being used in most places where they are better adapted than other materials. Also, cost economies for the phenolics have been quite fully worked out and competition has brought their prices down to the point where they probably cannot go much lower. They are the cheapest of all plastics materials. Much the same reasoning would apply to the cellulosic plastics, which have been on the market a number of years. Moreover, the cellulosic plastics are limited in their raw material sources to cotton and wood, natural materials, for which the cost of production cannot be reduced very much.

But there is still much room for future expansion in uses, and reduction in the cost of manufacture, of many of the new types of synthetic plastics which have been developed during the past 10 or 15 years and it is these which have the most interesting long-range possibilities.

1946 Production of Plastics and Synthetic Resins

	Thousands of Lb.
Cellulose acetate and mixed ester plastics	
Sheets, rods, and tubes	19,865
Molding and extrusion materials	83,204
	103,069
Nitrocellulose plastics	
Sheets	10,932
Rods and tubes	7,230
	18,162
Phenolic and other tar acid resins	
Laminating (dry basis)	27,606
Adhesives (dry basis)	15,665
Molding materials	140,216
All others, including casting (dry basis)	57,859
	241,346
Polystyrene	66,791

	Thousands of Lb.
Urea and melamine resins	
Adhesives (dry basis)	40,793
Textile and paper treating (dry basis)	13,535
All others, including laminating (dry basis)	3,747
	58,075
Vinyl resins	
Sheeting and film	21,609
Textile and paper coating resins (resin content)	26,192
Molding and extrusion materials (resin content)	63,590
All others, including adhesives (resin content)	27,466
	138,857
Miscellaneous plastics and resins	
Molding materials	61,289
All others (dry basis)	35,565
	96,854

Source: Bureau of the Census, U. S. Department of Commerce.

Closing Date Approaches for Entries for the

1947 MATERIALS & METHODS Achievement Award

As announced in our January issue (page 56) the closing date for entries in the 1947 MATERIALS & METHODS Achievement Award is June 30, 1947. This Award, established to honor those doing outstanding current work in the development, application and processing of engineering materials, will be given in 1947 specifically for the most significant use of modern engineering materials and processing methods to increase production and reduce the cost of products now being manufactured. This "theme" has been widely hailed as the most timely that could have been selected for an industrial achievement award in this particular year.

Classifications

Awards will be conferred in the following classifications:

(1) **One Grand Award.**
(2) **Three Special Awards for achievement in**
  (a) **selecting and applying materials,**
  (b) **developing new engineering materials, and**
  (c) **process or equipment developments**

all resulting in increased production and lowered costs.
(3) **Honorable mentions in all classifications.**

The Judges

In the adjoining panel we are proud to present the Committee of Award for the 1947 competition, the seven nationally prominent engineers and production executives who will appraise the achievements submitted for award consideration.

RALPH M. HEINTZ

Vice President, Jack & Heintz Precision Industries, Inc., Cleveland. Inventor and developer of many electrical, electronic and mechanical devices. Co-founder of Jack & Heintz, which so startled industry by its phenomenal growth and production record on aircraft, Navy and Army equipment during the war (and which also won an Honorable Mention in the 1946 MATERIALS & METHODS Achievement Award for the development of an internal combustion engine making efficient use of light metal die castings). Mr. Heintz is a Fellow of I.R.E.; Fellow, A.I.E.E.; Member A.S.M.E. and S.A.E.

NORMAN L. MOCHEL

Manager, Metallurgical Engineering, Westinghouse Electric Corp., Philadelphia. One of the country's leading specialists in, and an outstanding wartime worker on, materials and processes for steam and gas turbines and other high-temperature equipment. Served in Engineer Corps in World War I. Has spent entire business career with Westinghouse. Active A.S.T.M. worker, now Chairman of Committee A-1 on Steel, and of the Joint A.S.T.M.-A.S.M.E. Joint Research Committee on the Effect of Temperature on Metals. Also member of A.I.M.E., A.W.S., A.S.M., A.S.M.E. and Franklin Institute.

LOUIS F. POLK

President of the Sheffield Corporation, Dayton, Ohio, and of Threadwell Tap & Die Co., Greenfield, Mass. Was vice president and general manager of Sheffield's predecessor company, and was elected president of Sheffield on its formation in 1941. Expert in manufacturing and engineering problems associated with machine-tools, gages, precision instruments, small parts, taps, dies, etc., his companies being acknowledged leaders in their fields. Member of A.S.M.E., S.A.E., A.S.T.E., American Gage Design Committee of National Bureau of Standards, and a charter member of the Air Power League.

Judges

The entries for this Award will be reviewed and judged by a Committee of Award comprising the following seven distinguished manufacturing, design or research executives:

Ralph M. Heintz, Vice Pres., Jack & Heintz Precision Industries, Inc., Cleveland

Norman L. Mochel, Mgr. Metallurgical Engrg., Westinghouse Electric Corp., Philadelphia

Louis Polk, President, The Sheffield Corp., Dayton, Ohio

A. M. Sargent, President, Pioneer Engineering & Mfg. Co., Inc., Detroit

Walter Dorwin Teague, Industrial Designer, New York

Sam Tour, President, Sam Tour & Co., Inc., New York

J. R. Townsend, Materials Engr., Bell Telephone Laboratories, Murray Hill, N. J.

Their photographs appear elsewhere in this article.

Form of Entries

Entries will be accepted from any individual, company or department of a company engaged in the manufacture or development of mechanical, electrical or other fabricated products or parts, or of materials and processing equipment for such products —whether or not a subscriber to, or advertiser in, this magazine.

To enter, each candidate must send a formal entry to the Award Secretary, consisting of a statement of 500 to 1000 words factually describing the development or achievement involved, with specific proof of its production and cost benefits. Entries should be addressed to:

Fred P. Peters, Secretary, Award Committee, MATERIALS & METHODS, 330 West 42d St., New York 18, N. Y.

The winners will be announced in the October 1947 issue of MATERIALS & METHODS, and will receive their plaques and certificates at a special presentation dinner in Chicago during the week of October 20th.

But remember—the closing date for all entries is June 30, 1947—and it will be here soon!

A. M. SARGENT

President and General Manager, Pioneer Engineering & Mfg. Co. Prominent production engineer, currently National President of American Society of Tool Engineers. Served in engineering and executive capacities in automotive and machinery manufacturing fields (Studebaker, Chevrolet, C. G. Spring & Bumer Co., Michigan Machine Co., Burroughs, Universal Wrench), with several inventions of special machines and production devices to his credit. Frequent author of trade and technical articles. Has been president of Pioneer Engrg. & Mfg. Co. (also of Pioneer Pump & Mfg. Co. and Pioneer Industries) since 1931.

WALTER DORWIN TEAGUE

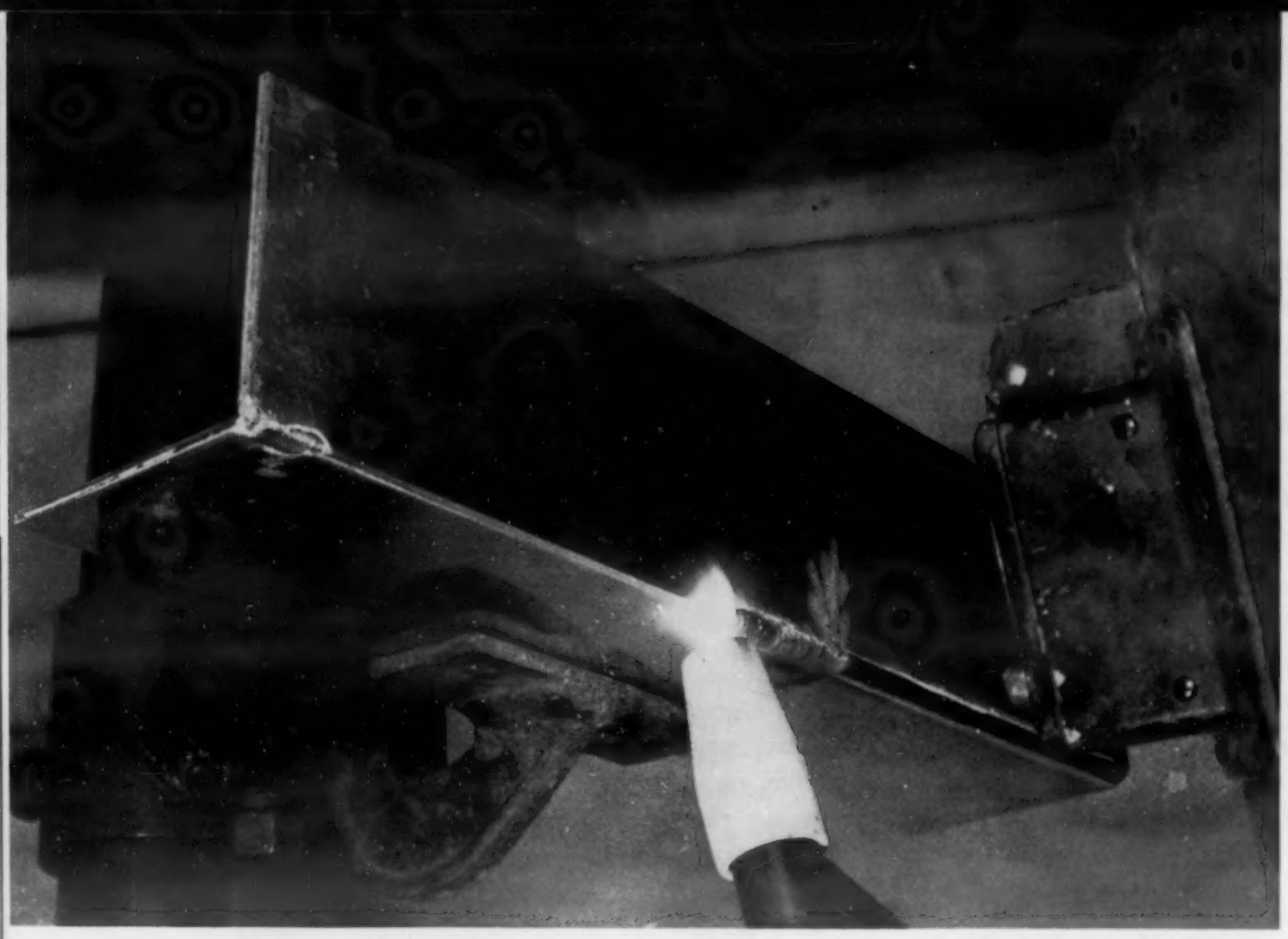
Outstanding industrial designer, with offices in New York and Los Angeles. Designed the first stream-lined lightweight railway cars. Has been designing automobiles, airplanes, cameras, household appliances, machines, packages, etc., for over 20 years, frequently experimenting with new materials and production processes. Author of "Design This Day" (1940) and "Land of Plenty" (Feb. 1947). Recipient of American Design Award (1939), the Advertising Award (1940) and the Naval Ordnance Development Award (1946). A founder and first president of Society of Industrial Designers.

SAM TOUR

President, Sam Tour & Co., Inc., engineers, metallurgists and consultants. National authority in materials-and-process-engineering, metallurgy, foundry practice, chemical processing, tests, standards and related fields, for over 30 years. From 1929 to 1943, vice-president of Lucius Pitkin, Inc.; since 1943 head of his own firm. Prolific author. Long record of technical society committee activity and wartime service with government agencies. Member of A.F.A., S.A.E., A.I.Ch.E., A.I.M.E., A.S.M., A.S.T.M. and Assoc. of Consulting Chemists and Chem. Engrs. Especially active in A.S.T.M., and now on its Executive Committee.

JOHN R. TOWNSEND

Materials Engineer, Bell Telephone Laboratories, Murray Hill, N. J. Indefatigable and influential promoter of materials selection based on sound economics and manufacturing adaptability. Served in Ordnance Dept., World War I; Western Electric Co., 1919-1925 and Bell Labs after 1925. Author of many technical papers on materials, tests and standards. During World War II served with several Government organizations. Member of A.S.T.M., A.W.S., A.S.M.E., Standards Council of A.S.A. Awarded A.S.T.M.'s Dudley Medal in 1930. National President A.S.T.M., 1945-1946.



All position welding can be performed with the Heliarc process. Here a corner weld is being welded in the overhead position.

Inert-Gas-Shielded Arc Welding for Difficult-to-Weld Materials

by **H. R. CLAUSER,** *Associate Editor,* MATERIALS & METHODS

SINCE ITS EARLY DEVELOPMENT during the war, inert-gas-shielded arc welding has become a dependable and versatile welding method. It is now being used successfully for joining many metals and alloys difficult to weld by other processes. Uniform, high-quality welds can be obtained on such materials as stainless steels, aluminum and aluminum base alloys, magnesium and its alloys, and many other nonferrous metals.

In inert-gas-shielded arc welding, commonly termed Heliarc welding, an arc is struck between the work and a single, virtually non-consumable tungsten electrode while a monatomic inert gas flows around the electrode and envelopes the weld zone. The arc melts the material to be welded, and the gas shields the weld metal and prevents oxidation. Depending on the application, a welding rod may or may not be fed into the welding zone in much the same manner as in oxy-acetylene welding, but no flux is required.

Although helium was originally used as the shielding gas, argon gas is now generally used for several reasons. High purity argon is available in large quantities; it is a heavier gas and shields the weld puddle more effectively; and with it, all metals can be welded without any flux.

Standard welding power equipment is in general acceptable for gas shielded arc welding. Direct current generators normally used for metallic arc welding

are quite suitable. Alternating current transformers are also suitable, but for best operation should be equipped with low-power high-frequency generators. The high frequency current stabilizes the arc and allows the use of longer arcs and easier welding conditions.

The welding torch which holds the tungsten electrode and dispenses the argon, is water cooled; the water circulates through the body of the torch and completely surrounds and cools the power cable.

Highly valuable in joining light metals, Heliarc welding appears to be extremely practical for those other metals which normally present welding difficulties.

Variety of Materials Can Be Welded

The Heliarc welding process gives excellent welding results on a great variety of materials. These include practically all commonly welded metals such as stainless steel, magnesium, aluminum, Hastelloy alloys, Everdur and various brasses, silver, Inconel, copper-nickel, Monel, phosphor bronze, and nickel, but not carbon steel and copper. It has also been used with considerable success to coat silver and silver alloys on steel, stainless steel and aluminum bases, and to apply hard surfacing rods on steel.

Test work on stainless steel welds to date indicates that weld joint strength in Grade 302 is 90 to 95% of the base metal in ultimate tensile strength. On bend specimens, elongations from 48 to 60% in 2-in. gage length have been obtained. Analysis of the weld metal shows no increase of carbon; and of particular interest, no measurable loss of chromium, nickel or other alloys occurs. It is believed that this retention of alloys, ordinarily lost, is due to the excellent protection of the weld puddle from the atmosphere. This means that filler rods without increased nickel content and in general similar to the base metal can be used to produce a weld joint with a composition equivalent to the base metal.

Where high speeds, possible with mechanized welding, are employed, corrosion resistance in the as-welded condition is usually greater than in welds made under similar conditions with other fusion welding processes. However, with poor fitup and improperly low current values, greater heating may take place in the weld area and result in undesirable carbide precipitations in those analyses subject to this phenomenon.

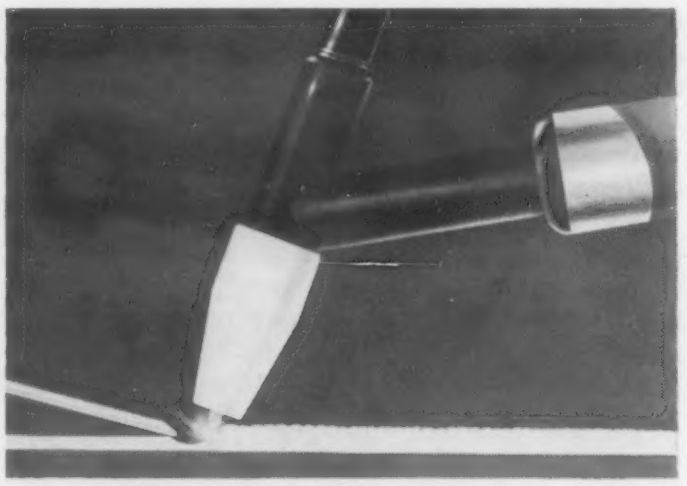
Non-heat-treatable aluminum alloys when welded by the Heliarc process show average weld strengths equivalent to the base metal strength in annealed sheet. Somewhat higher values are obtained in work-hardened tempers. Heat-treatable aluminum materials will have an ultimate tensile that averages 50 to 80% of the heat treated condition. In these alloys the ductility will depend upon the alloy and previous heat-treatment. The corrosion-resistance of 2S, 3S and 52S aluminum, as measured by salt spray tests, equals the resistance in the annealed condition. This indicates superior corrosion resistance to that obtained by any other fusion welding method. The elimination of flux and the absence of danger of corrosion from incomplete flux removal or entrapped flux is one of the major advantages of the process on aluminum. The process itself does not impose limitations on the selection of rod composition and, therefore, high purity (2S) welding rods can be used where desired for greater corrosion resistance.

Although results of test work on Everdur welds are not available at present, qualifying tests for production use in fabrication of vessels show that an ultimate tensile strength of 50,000 psi. or better with an elongation of 30% is readily obtained.

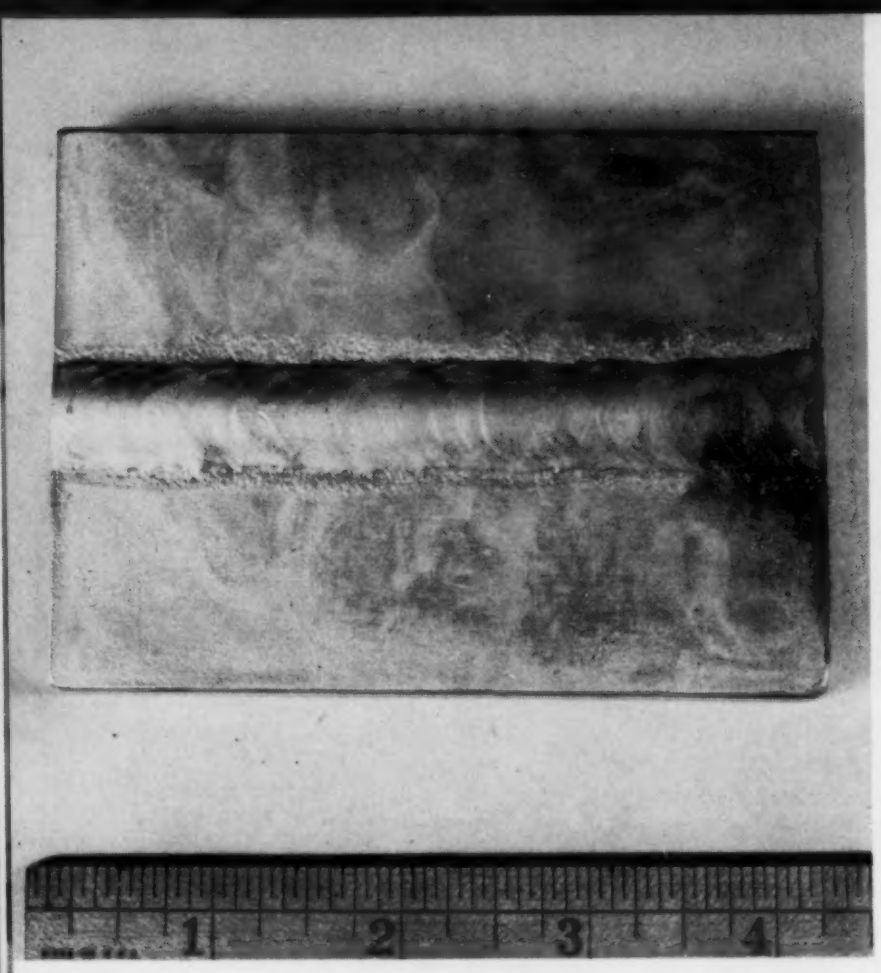
Process Characteristics

For practical reasons it is generally considered that the low limit of thickness—that is, the thinnest material—which may be hand welded averages 1/32 in. The melting and distortion of material thinner than this is too difficult to control for successful hand welding. Machine welds have been made on material as thin as 0.005 in. in production, but these have been rather specialized applications that allowed close holding of the joint shape. A greater variety of production applications are possible with material not thinner than 0.025 in.

The maximum thickness which may be welded at the present time is limited by available equipment. A 500-amp. hand welding torch now available will allow production plate welding as follows: aluminum with no preheat, 5/8 to 3/4 in., and with 300 to 400 F preheat, about 2½ in.; stainless steel, using no preheat, up to ½ in.; Everdur with no preheat, up to 3/4 to 1 in.; magnesium up to and including 1 in.



In this close-up the essential elements of the Heliarc welding process are shown in their position relative to the work piece.



A ½-in. thick magnesium alloy plate was welded with one pass. Note the excellent appearance of the weld surface.

Most metals up to and including 1/16 in. can be welded without filler metal, and welds will be produced having a thickness equal to or slightly greater than the base metal if the edges are tightly butted.

The appearance of finished welds is especially good because no flux is employed and no spatter is deposited in the vicinity of the weld. Under most operating conditions the protective gas prevents heavy oxidation on the weld surface. For instance, in stainless steel reddish to purplish oxide tint colors are all that remain on the surface of the weld. Therefore, clean-up is easier with this type of welding than with most other methods. Interpass cleaning is also minimized.

Easy control of amount of filler metal deposited provides exceptionally good contour control of the finished weld shape, which makes removal of excess weld metal unnecessary and decreases cleaning costs. Reports from production use show decreases of 40 to 80% in cleaning costs as compared to standard metallic arc procedures. This also is important in casting alteration and repair where welding may be done on finished shapes and still maintain the foundry tolerances. Various treatments employed on aluminum to improve corrosion resistance of surfaces, such as anodizing, show a better color match between the weld zone and base metal than obtained by other fusion welding processes.

The Heliarc process allows all-position welding; practical procedures have been developed for butt, lap and fillet welds in horizontal, vertical and overhead positions. However, as in other welding processes, welding rates are generally higher and operator skill requirements less severe for welding in the horizontal position. Therefore, overall savings will be realized with careful planning of design and setup to allow as much down-hand position welding as possible.

The high welding rates possible and the localized heating zones eliminate much of the distortion commonly associated with fusion welding, particularly oxyacetylene welding of aluminum. One aluminum tank fabricator found it possible to reduce welding on an 8-ft. dia., ⅜-in. girth seam from 11 hr. to 2 hr. 15 min. by substituting Heliarc welding for oxyacetylene welding. In addition, savings were made by complete elimination of after-strengthening and flux removal. In another case, a bus manufacturer eliminated the need of after-sizing and straightening when welding window frames on bus sides.

Costs

The cost of using any welding process is made up of several factors in addition to the actual cost of materials used in making the weld. Joint preparation cost is one of these. In many cases joint preparation using this process is similar to that of other welding methods and, therefore, costs are about equal. The rate of welding will in many cases depend upon the type of joint and will sometimes be higher and sometimes lower than other kinds of welding. Probably the major cost advantage of the Heliarc process is in the reduction of flux removal, and of weld and inter-pass cleaning costs.

To arrive at an approximate idea of actual welding costs, the following information is given. The major cost is for protective gas. Argon in high purity welding grades averages about 10c per cu. ft. and helium about 8c per cu. ft. Approximately 2½ to 3 times more helium is required for a given amount of welding than is required for the same amount of work using argon. The cost of helium may then be expected to be from 1½ to 2 times as much as argon. The following costs are based upon the use of argon and represent extreme conditions: welding very thin material, 0.025-in. thick, at the rate of 48 ipm., and welding ½-in. thick material at a total welding time rate of about 2 to 3 ipm.

The gas cost for the 0.025-in. thick material is approximately 50c per 100 ft. of weld; for the ½-in. thick material it is between 20 and 30 dollars per 100 ft. of weld. Tungsten electrode costs vary from about 1 to 3% of the gas cost; power costs from about 1 to 5% of the gas cost, the lower percentage being for the light material and the high percentage for the heavy material. The above limiting conditions are for mechanical welding of the light material, while hand welding is assumed for the heavy material.

To compute overall welding costs, it is important to know that the operating factor or arc time averages between 50 and 60%. This comparison with approximately 40% by metallic arc methods is explained mostly by the fact that little or no inter-pass cleaning is required. The amount of gas consumed will be

equal to the hourly rate of flow times arc time plus an allowance of about 5 to 10%. The protective gas must not be turned off immediately when the arc is extinguished, because the tungsten electrode will tend to oxidize and deteriorate unless the protective gas flow is allowed to continue until the electrode cools. This 5 to 10% allows for such electrode protective flow.

Design Considerations

The proper design of parts to be welded is an important factor in the ease with which the welding operation is performed. For the Heliarc process, stainless steel, Everdur, and, to a limited extent, magnesium need not have abutting edges of the same thicknesses. However, in aluminum fabrication, the high conductivity of the metal makes it extremely important to have equal abutting edges. For instance, where castings or forged parts are to have wrought sheet or tube attached, the casting or forged piece should be tapered or machined down so that it has a thickness approximately equal to the wrought material. In some cases this may not be possible due to other limitations. In such instances it is possible to provide complete weld penetration for the depth of the wrought material by relieving the casting in the vicinity of the joint.

Because this process employs an arc between a virtually non-consumable electrode and the work and because the filler metal is added externally, maximum economy and speed are obtained when various flange or corner joints are used where the thickness allows. On joints of this type, no filler metal is required. In greater thicknesses, where flanging, etc., is not possible or feasible, beveled joints are employed. The joint design for this process resembles, in the dimensions employed, the designs used for submerged melt welding rather than designs for metallic-arc hand welding. In this respect square butt joints are used in greater thicknesses than in metallic arc welding, and, where bevelled joints are employed, a square nose is employed as distinct from the single bevel and no nose preparation common in metallic arc hand welding.

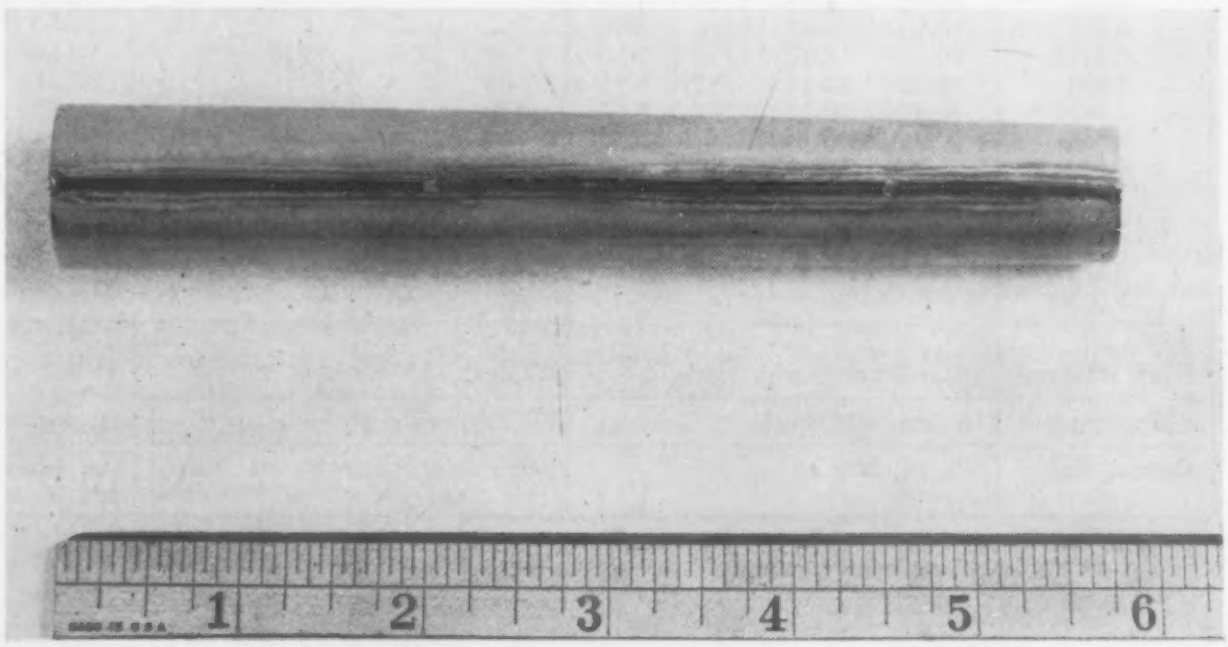
Welding Procedure and Technique

In general, welding procedure and operation with Heliarc welding follows the same general principles common to other fusion welding processes. As with other types of welding, cleaning prior to welding is important and the importance varies somewhat with the type of material. Small amounts of foreign material on stainless steel and Everdur will not particularly harm the weld progress, but may result in weld contamination and therefore should be removed. Oil and grease may be removed with suitable solvents; scale, if any, by use of mechanical or chemical means.

Aluminum and magnesium, because of their tendency to oxidize readily, require more careful cleaning to avoid interference with the welding action. In many cases mechanical cleaning with steel wool is satisfactory, but for best results chemical treatments, particularly for welding at high speeds and/or thin materials, are required. The cleaning of magnesium will depend somewhat on the type of alloy and previous surface treatment it has received. In aluminum welding, degreasing should first be employed if the material has oil or grease deposits. This should be followed by an acid or, better yet, a caustic nitric hydrofluoric treatment with cold water rinse between treatments and a hot water final rinse to speed drying.

Since no flux is used and in general less oxidation of the weld surface occurs than with many other welding methods, much less inter-pass cleaning is required. A light hand brushing is all the cleaning necessary, and frequently this is not required.

Most metals up to and including 1/16 in. can be welded without filler metal, and welds will be produced having a thickness equal to or slightly greater than the base metal if the edges are tightly butted. In mechanical welding the pieces should be accurately mated and work holding jigs or fixtures must be pro-



This tea kettle spout of 0.035-in. stainless steel was welded at the rate of 42 in. per min.

vided to insure proper alignment of the edges, and prevent distortion. All such clamping means, when used to hold sections longer than approximately 6 in., should be segmented and the segments individually loaded so that each segment will apply equal force to the material being welded. In many cases they should also be mounted pivotally so that they can accommodate themselves to any irregularities of the work.

On many items of manufacture, having material in thicknesses of ¼ in. and greater, the plates are self-supporting and can be merely tacked together and then mechanically welded. It is extremely important in making such tacks, however, that they be made with the Heliarc process. The use of any other method of tacking, particularly those which employ a flux, will tend to produce porous spots in the finished weld due to the unremoved and entrapped flux in the tacks.

Some type of backup is beneficial, particularly for welding magnesium and aluminum. The advantage of using backup where possible is that it produces a less critical welding operation; also somewhat greater latitude in fitup and welding conditions can be tolerated. The backup material found most suitable for stainless steel is copper or other material having a high conductivity which will not melt in case of burn-through. While copper backing may also be used on aluminum or magnesium, it is more satisfactory to employ a material having a lower coefficient of heat conduction such as carbon or stainless steel.

Direct current with either straight or reverse polarity, or alternating current with high fequency stabilization may be used as welding power. The choice in some cases will depend upon the particular metal. For example, direct current straight polarity cannot be used on aluminum welding without flux and, therefore, alternating current with high frequency stabilization is usually employed. Reverse polarity direct current may be used, but because of the low heat input to the work and the high heating effect on the electrode, this type of current is seldom employed and is not suitable for material over about 1/16-in. thick.

In general, for such materials as stainless steel, which may be welded with direct current straight polarity or alternating current, best results are obtained with alternating current on materials of about 0.050 in. and thinner with welding currents of 75 amp. or less. For material thicker than this and higher welding currents, direct current straight polarity would be the best choice because it usually gives the highest welding speed.

Welding conditions that may be employed, meaning the current and rate of travel, on the various materials covers a very wide range and depends upon the type of operation. The table accompanying this article indicates these general conditions and covers operations extending all the way from slow hand welding work of inexperienced operators and poorly fitted joints to the highest speed operations represented by mechanized welding on carefully fitted and jigged materials.

The information and data for this article were supplied by the Linde Air Products Co. The author wishes to thank H. T. Herbst and F. J. Pilia of that company for their valuable assistance.

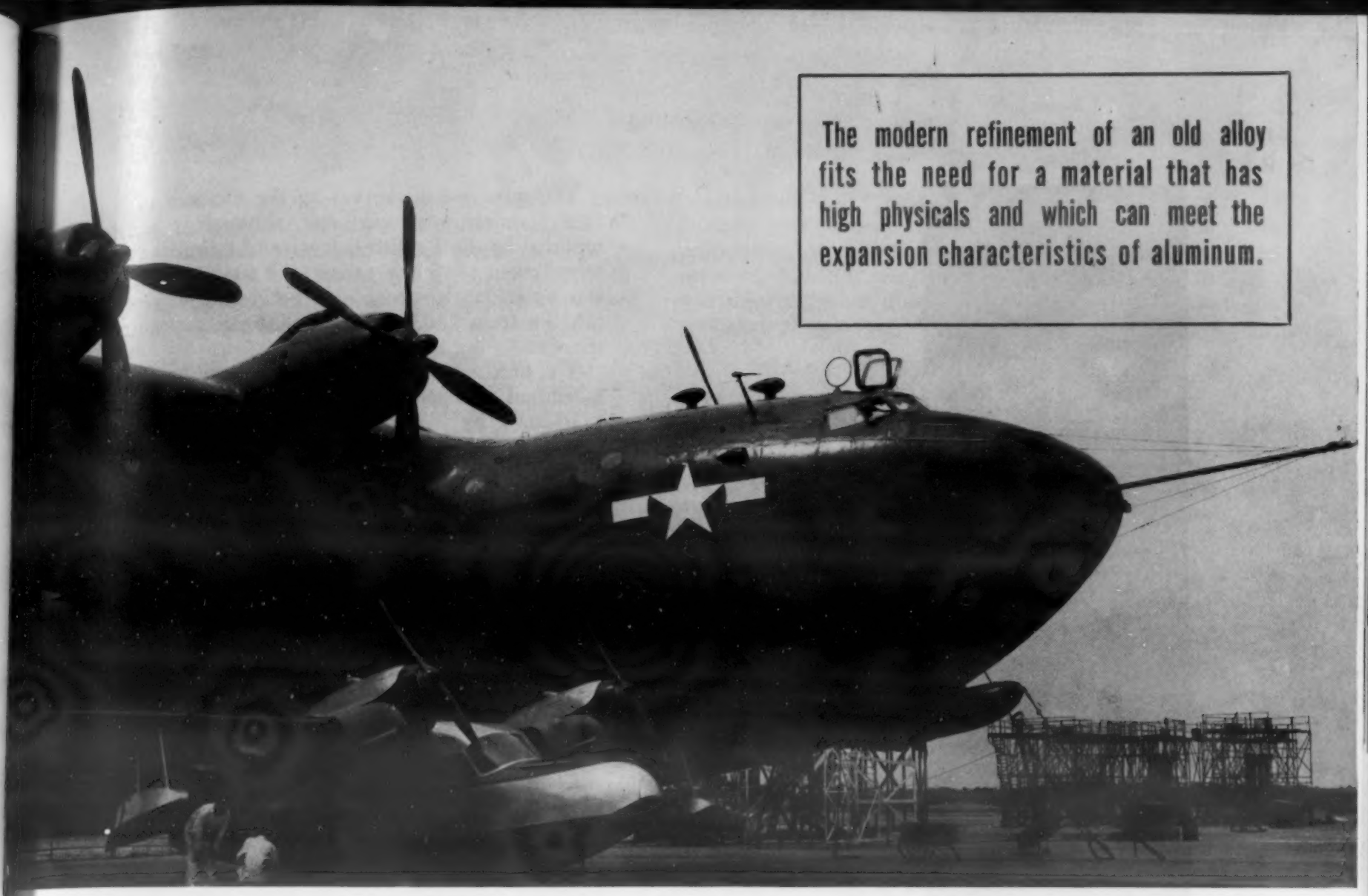
General Operating Data For "Heliarc" Welding

Thickness, In.	Aluminum				Magnesium				Stainless Steel			
	Current Range, Amp.	Argon Flow, Cfh.	Rod Size, In.	Arc Speed, Ipm.	Current Range, Amp.	Argon Flow, Cfh.	Rod Size, In.	Arc Speed, Ipm.	Current Range, Amp.	Argon Flow, Cfh.	Rod Size, In.	Arc Speed, Ipm.
0.025	10-75	8-12	1/16	3-50	—	—	—	—	20-40	6-7	1/32	15-40
0.031	10-90	−8-12	1/16	3-50	—	—	—	—	25-40	6-7	1/32	15-40
0.0375	20-100	8-12	1/16	3-50	40	8	1/16	12	50-130	6-7	1/16	15-40
0.050	50-200	10-14	3/32	5-15	45	8	1/16	12	80-225	6-10	1/16	5-60
0.0625	70-200	10-14	3/32	5-15	50	8	3/32	12	80-250	6-10	1/16	5-60
0.0781	80-250	10-14	1/8	5-40	60	8	3/32	12	80-300	6-10	3/32	5-60
0.109	200-300	12-16	1/8	5-30	70	10	1/8	12	140-350	8-12	3/32	5-30
0.125	200-400	12-16	3/16	10-30	80	10	1/8	10	150-375	8-12	1/8	5-30
0.195	250-400	12-16	3/16	10-30	100	12	3/16	10	200-425	10-14	1/8	5-30
0.250	250-500	14-20	3/16	6-16	100-435	16	3/32	15	250-450	15-20	3/16	3-20
0.375	350-450	14-25	1/4	5-10*	100-250	16	3/16	12*	300-500	15-20	3/16	3-18
0.500	400-500	20-30	1/4	5-10†	150-275	16	3/16	8*	350-600	15-20	3/16	3-12
B/P Angle (for Hand Welding)	45 to 70 deg. with work				90 deg. with work				45 deg. with work			
Rod Angle	10 deg. with work				10 deg. with work				10 deg. with work			
Oxweld Rod	No. 14, No. 23				Same composition as base metal (see note)				Use No. 28 for 300 Series			

Values on the high end of the current and speed ranges are for mechanical welding, the lowest for inexperienced operators or badly fitting work, while intermediate values are for experienced hand operators.

* *2 Passes.*

† *5 Passes.*



The modern refinement of an old alloy fits the need for a material that has high physicals and which can meet the expansion characteristics of aluminum.

Modern airplanes, which are exposed to great temperature changes, require control cable materials of high thermal expansion to maintain proper control cable tension.

Nickel-Manganese-Chromium Steel Wire for Aircraft Control Cables

by **HENRY C. BOYNTON,** *Consulting Metallurgist*

A NEW NICKEL-MANGANESE-CHROMIUM STEEL, patterned after the manganese-nickel alloys developed by Hadfield in 1904, is now being used for aircraft control cables. Its coefficient of thermal expansion is so close to that of the structural aluminum alloys that the problems of maintaining proper control cable tension in aircraft operating over a range of temperatures is eliminated when this new alloy is used.

Although manganese-nickel alloys have been used in the fabrication of thermostatic bimetals and in special purpose castings of the "Ni-Resist" type, they had never been used as wires nor had their physical properties been fully investigated. Because of the need for a control cable wire that could be used in airplanes at altitudes at which the temperature reached −60 F or lower, an Eastern manufacturer's laboratory was commissioned to develop, from nickel-manganese-chromium steel, a wire that would be as strong as Type 304 Stainless Steel. The sizes required ranged from 0.010 to 0.020 in. in dia.

The analysis of the alloy chosen for this development work was:

Carbon	0.30 to 0.70%
Manganese	3.50 to 6.00%
Nickel	11.0 to 14.00%
Chromium	3.0 to 6.00%

Coefficient of expansion determinations were made in this apparatus, which is patterned after the equipment used by Souder and Hidnert of the Bureau of Standards.

The wire was processed by the methods used for 18:8 stainless steel wire, and, although it had been reported by the English that wire of a similar analysis tested about 10% lower than 18:8 stainless steel, there was no particular trouble in processing to strengths ranging from 250,000 to 280,000 psi., depending on the size.

The finished nickel-manganese-chromium steel was fabricated into standard sizes of aircraft cable, from 1/16-in. 7 by 7 to 3/16-in. 7 by 19 construction. Larger sizes could, of course, be manufactured as needed.

Physical Properties

In the form of rods or bars, nickel-manganese-chromium steel has the following physical properties:

Tensile strength	112,000 to 145,000 psi.
Yield point	67,000 to 125,000 psi.
Elongation in 2 in.	30 to 60%
Reduction of area	30 to 60%
Modulus of elasticity	28,600,000 psi.

As cold-drawn wire of 0.010- to 0.020-in. dia., its physical properties are:

Tensile strength	240,000 to 280,000 psi.
Elongation in 10 in.	1.0 to 1.5%

Its magnetic permeability ranges from 1.003 to 1.008.

Stranded cable composed of 7 strands, 7 wires per strand, or 7 strands of 19 wires per strand have the following breaking strengths:

Cable Dia., In.	Cable Construction	Breaking Strength, Lb. (Tentative)
1/16	7 by 7	384
3/32	7 by 7	736
1/8	7 by 19	1500
5/32	7 by 19	2080
3/16	7 by 19	3120

Table I—Analyses of Specimens Tested for Coefficient of Thermal Expansion

All specimens tested as cables were of 7 by 19 construction

Type	Size, In.	C	Mn	Si	Cu	Ni	Cr	Mg	Mo
17ST Tubing	3/16-O.D. - 0.053-I.D.	—	0.55	0.45	4.10	—	—	0.55	—
24ST Tubing	3/8-O.D. - 0.058-I.D.	—	0.60	0.16	4.40	—	—	1.38	—
61ST Tubing	3/8-O.D. - 0.058-I.D.	—	—	0.47	0.27	—	0.24	0.91	—
Carbon Steel Cable	5/32	0.55	0.53	0.21	0.07	0.06	—	—	—
Carbon Steel Cable	3/16	0.55	0.57	0.21	0.07	0.07	—	—	—
304 Stainless Cable	5/32	0.07	0.44	0.35	—	8.90	18.60	—	—
304 Stainless Cable	3/16	0.08	0.46	0.39	—	8.92	18.45	—	—
316 Stainless Cable	3/8	0.06	1.67	0.37	—	13.36	17.72	—	2.38
Mn-Cr Steel Cable	5/32	0.12	15.80	0.20	—	0.26	12.60	—	—
Ni-Mn-Cr Cable (Lot 1)	5/32	0.44	5.00	0.43	—	12.56	4.02	—	—
Ni-Mn-Cr Cable (Lot 2)	5/32	0.31	6.00	0.42	—	11.89	3.91	—	—
Carbon Steel Cable	3/16	0.62	0.58	0.21	0.10	0.08	—	—	—
Clad with 61ST Tubings	—	—	—	0.49	0.24	—	0.24	0.90	—
Ni-Mn-Cr Cable (Lot 1)	5/32	0.43	5.20	0.40	—	12.37	4.08	—	—
Clad with 17ST Tubing	—	—	0.50	0.49	3.90	—	—	0.58	—
Ni-Mn-Cr Cable (Lot 2)	5/32	0.30	5.90	0.43	—	11.88	3.85	—	—
Clad with 17ST Tubing	—	0.50	0.49	3.84	—	—	—	0.48	—

These values of breaking strength must be considered as tentative standards. Further work should permit increases in the load values given.

Investigations of the fatigue strength of nickel-manganese-chromium steel are now under way. However, no results are available as yet.

Coefficient of Expansion Tests

Coefficient of expansion tests on both the wire and the fabricated cable were conducted at temperatures between 75 and −65 F. Similar tests were made on tubing of various aluminum alloys and on carbon and stainless steel cables. Some of the cables were encased in aluminum alloy tubing. Table I gives the analyses, forms and sizes of the specimens tested.

Details of the method by which the expansion coefficients were determined were:

(1) The dials showing the changes in length were read through a window from an ante-room of the refrigerator, which was at 0 F.

(2) Temperature inside the cold chamber was measured by toluol thermometers placed near the apparatus.

(3) Change in length was measured in comparison with a standard fused quartz tube, as suggested by Souder and Hidnert.

(4) The quartz tube was checked by comparison with steel tubing, and a change of 0.001 in. was noted in the range from 75 to −65 F. This correction was made in the calculations.

(5) All test results were successfully checked on duplicate samples.

The coefficients of expansion determined by these tests are given in Table II. The nickel-manganese-chromium alloy cables have coefficients that closely approach those of the aluminum alloys. Encasing the nickel-manganese-chromium cable in aluminum alloy tubing increases the coefficient of the assembly so that it is practically equal to that of the aluminum alloys.

The change in the thermal coefficient of the nickel-manganese-chromium alloy over the range of temperatures investigated is much lower than that of any of the other ferrous alloys. The nickel-manganese-chromium cables encased with 17ST aluminum alloy tubing showed a much lower rate of change than the cable alone.

Encasing plain carbon steel cable with 61ST tubing produced an assembly that showed higher thermal coefficients and lower rates of change than the stainless or manganese-chromium alloys.

Additional work was started on determining the effect of cold working by wire drawing on the thermal expansion properties. It was found that the thermal expansion properties of nickel-manganese-chromium steel were lowered only slightly by a total reduction in area of 80%. Type 304 stainless was affected much more by wire drawing in the lowering of its expansion properties. Moreover, regular 18:8 stainless steel becomes decidedly magnetic with 80% or more of wire drawing, while nickel-manganese-chromium steel appeared to gain very little in magnetism.

Applications of Nickel-Manganese-Chromium Steel

Complete data on the physical properties of nickel-manganese-chromium steel are not yet available. Until these data are obtained, application of this alloy will be limited. Actual experience has shown that nickel-manganese-chromium steel is entirely satisfactory for use in aircraft control cable. Its high thermal expansion coefficients should permit its use in the fabrication of thermostatic bimetals. However, additional information on its resistance to elevated temperatures is needed.

It has been used successfully for aircraft motor cylinder liners, valve seats and crank case bolts. This steel can be nitrided and is used for cylinder liners in this condition. Limited tests have indicated that this steel retains its strength and resistance to impact even at low temperatures. Further tests may indicate the suitability of this alloy for stress carrying members that must function at low temperatures.

Because it remains non-magnetic after severe cold working, nickel-manganese-chromium steel may be found suitable for applications that require a non-magnetic material with a strength greater than that of the nonferrous metals.

Table II — Thermal Expansion Properties of Aircraft Control Cables

Type	Size, In.	Coefficients of Thermal Expansion per deg. F x 10^{-6}		
		75 F	0 F	−60 F
17ST Tubing	3/16-in. by 0.053	12.5	12.0	11.2
24ST Tubing	3/8-in. by 0.058	12.6	12.1	10.8
61ST Tubing	3/8-in. by 0.058	13.0	12.1	10.8
Galv. Carbon Steel Cable	5/32	6.0	5.8	3.1
Galv. Carbon Steel Cable	3/16	6.5	5.8	2.2
Type 304 Stainless Steel Cable	5/32	7.7	6.4	3.1
304 Stainless Steel Cable	3/16	7.8	7.0	4.6
Type 316 Stainless Steel Cable	3/8	9.3	8.8	6.7
Mn-Cr Alloy Steel Cable	5/32	9.0	5.2	2.0
Ni-Mn-Cr Alloy Steel Cable (Lot 1)	5/32	10.3	9.0	6.0
Ni-Mn-Cr Alloy Steel Cable (Lot 2)	5/32	10.7	9.6	7.5
Carbon Steel Cable Clad with 61ST Tubing	3/16	9.6	9.3	8.6
Ni-Mn-Cr Alloy Steel Cable Clad with 17ST Tubing, (Lot 1)	5/32	11.5	11.1	10.2
Ni-Mn-Cr Alloy Steel Cable Clad with 17ST Tubing, (Lot 2)	5/32	12.2	11.3	9.4

Although its many possibilities are unexplored, properties of this new alloy indicate its potential use for many applications other than springs.

With Elgiloy came an innovation in watch making, through use of a welded brace assembly. Tests show that this construction is more rigid and at least two or three times stronger than the older method of riveting.

New Strong, Nonmagnetic Spring Material Has High Corrosion Resistance

NEW MATERIAL PREVIEW

A new alloy, the first application of which is in long-lived watch springs, was recently announced by the Elgin National Watch Co., Elgin, Ill. Named Elgiloy, the new material is strong, relatively hard, nonmagnetic, highly resistant to corrosion, non-setting, and otherwise superior to high quality carbon steel spring materials.

The alloy was developed as a result of research pushed by Elgin for several years and shared in by several other organizations including Battelle Memorial Institute, Hoskins Mfg. Co., Wilbur B. Driver Co., and Athenia Steel Co. It was created in an effort to supply a watch spring material which would retain its full strength over a long period, reduce mainspring breakage, and help watches retain their accuracy.

Although Elgin has not yet made public the composition of Elgiloy, it has been reported to be as follows:

Chromium	20%
Cobalt	40%
Nickel	15.5 %
Iron	15. %
Molybdenum	7. %
Manganese	2. %
Carbon	0.15%
Beryllium	0.03%

In addition to its other favorable characteristics, Elgiloy is said to be remarkably ductile and to offer excellent workability when worked either hot or cold.

Processing Elgiloy into watch springs involves such processing steps as slitting ribbons of the material to proper width, cutting to length, punching, annealing, coiling, aging and spot-welding. No data have been furnished yet on machining properties of the material.

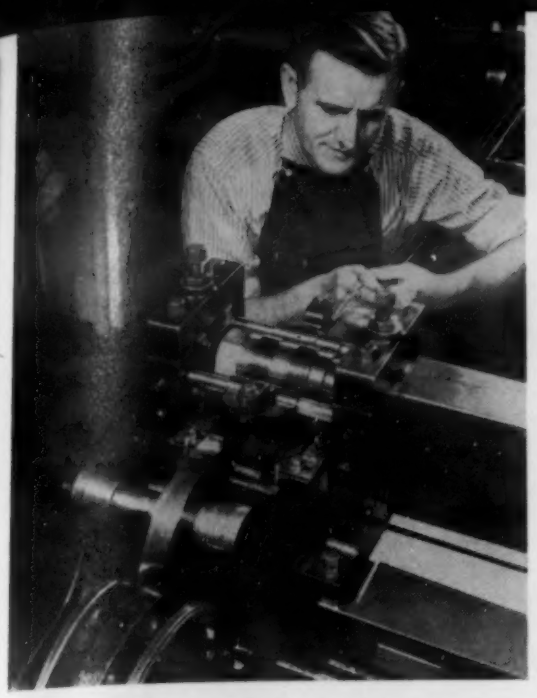
A comparison of the properties of Elgiloy with those of the carbon steel spring material formerly used shows:

	Elgiloy	*Carbon Spring Steel*
Ultimate Tensile Strength, Psi.	368,000	341,500
Yield Strength (0.02%), Psi.	280,000	248,000
Proportional Limit, Psi.	233,000	217,000
Modulus of Elasticity, Psi.	29,500,000	28,500,000
Vicker's Hardness Number	702	695

A comparison of watch-spring properties shows:

Spring Properties (15/0)	*Elgiloy*	*Carbon Spring Steel*
Delivered Torque (G.-CM.)	46.2	39.2
Wind Life (Average)	1036.0	565.0
Set After Wind Life (Turns)	3.8	6.0

Elgiloy is nonmagnetic under conditions involving

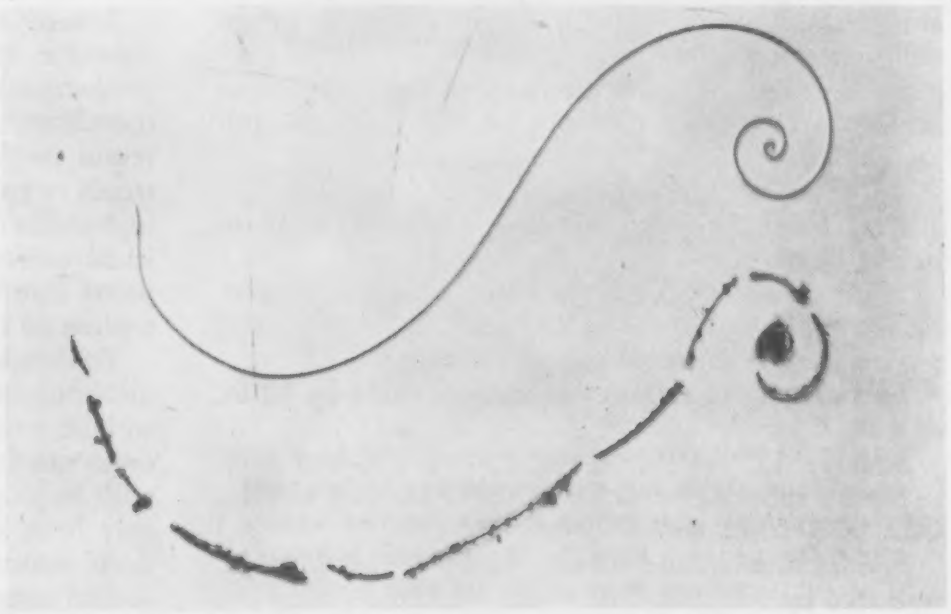


Elgiloy in a narrow band as it comes from the mill is being fed into a slitting machine. Because of its extreme hardness, Elgin engineers designed special equipment to polish and process the material.

Elgiloy does not demand a quenching and tempering heat treatment. However, main springs made of it are coiled in rings, given a furnace "aging" treatment.

both permanent and temporary magnetism. It is not affected by finger prints, high humidity, and showed no rust after 500-hr. exposure to a 10% salt spray. In a demonstration of its properties, Elgiloy was subjected to hot aqua regia for 12 min. without any harmful effect.

Although the use of Elgiloy is now restricted to watch springs because of limited output, it is expected in the future to find application in many products. Apparent possibilities include: razor blades, stainless cutlery, surgical and dental instruments, gun springs, valve parts, chemical equipment, automotive valve springs and parts, electronic components. In addition, the armed services are said to be investigating use of the material in jet propulsion, gas turbine and steam turbine equipment.



One carbon steel and one Elgiloy spring were placed at the same time in a sealed jar containing sufficient water to insure near 100% relative humidity. After 18 days the new alloy mainspring, left, was completely rust-free, while the carbon steel spring had disintegrated into several small, brittle sections.

With standard shapes of extrusions now available as stock items, this magnesium form should be investigated for use in many types of products.

Magnesium Extrusions Offer Fabrication Economies

by HERBERT CHASE

ALTHOUGH SOME MAGNESIUM EXTRUSIONS were available prior to the war, quantities were limited and such extrusions were rather expensive. At present, magnesium extrusions do not cost over 5% more per foot than aluminum extrusions. At least one company, the White Metal Rolling & Stamping Corp., Brooklyn, N. Y., now stocks many extruded shapes, rods and tubes. Too, stock extrusion dies are now available for standard and special shapes.

Now that many favorable characteristics of magnesium are available in a wide variety of shapes, that material is finding more and more applications in fields that were once restricted. One additional fact that is important is that magnesium alloys can be extruded through the same dies as are used for aluminum. Thus, it is a simple matter to switch from one material to the other.

Some indications as to the range of sizes and shapes available from stock dies can be had from the following list:

Round rod, ¼-in. to 5-in. dia. (1/16-in. steps up to 2⅛ in.).

Wire diameters, 3/32- to ¼-in. round and ⅛-in. sq. section.

Hex bar, ¼ in. to 4½ in. across flats.

Bars or strip of rectangular section, 0.032 by ⅜ in. to 4 by 4 in.

Squares, ¼, ⅜, ½, ⅝, ¾, 1, 1½, 2¾ and 4 in.

Round tube, ¼-in. O.D. by 0.032-in. wall to 5-in. O.D. by 3/16-in. wall.

Special non-circular tubing, ½ by ½ by 0.050-in. wall to 3 by 3 by 0.062-in. wall.

Angles, ½ by ½ by 1/16 in. to 3 by 3 by ¼ in.

Channels, 1 by ½ by 1/16-in. web to 5 by 1.885 by 0.325-in. web.

The normal extruded finish on magnesium is quite smooth and equal to that on other extruded materials. A grayish hydroxide film forms when extrusions are held in stock for long periods.

Normal hydroxide coatings attained in weathering are somewhat protective, quite resistant to abrasion and non-toxic but, in salt-laden and other corrosive atmospheres, white corrosion products appear on the surface. These are ordinarily not injurious, except in appearance, and can be avoided by any of several pickling, anodizing or other surface treatments.

Where appearance is not important and severe corrosive conditions are not encountered, extruded products can be used without protective coatings. All the alloys, however, take a high polish readily and retain it if the application is one in which (as in treads or handrails, for example) a continuing polishing action is applied. Ordinarily, however, the polished surface requires a coating of clear moisture-proof chloride-free plastic-base lacquer to insure retention of luster.

To date, magnesium has been applied chiefly where minimum weight or at least a minimum strength-weight ratio is desired, but the metal has numerous other attributes which the alert designer has used or will employ to advantage even where light weight may be a secondary or even a negligible consideration. Among these, the following are deserving of special mention:

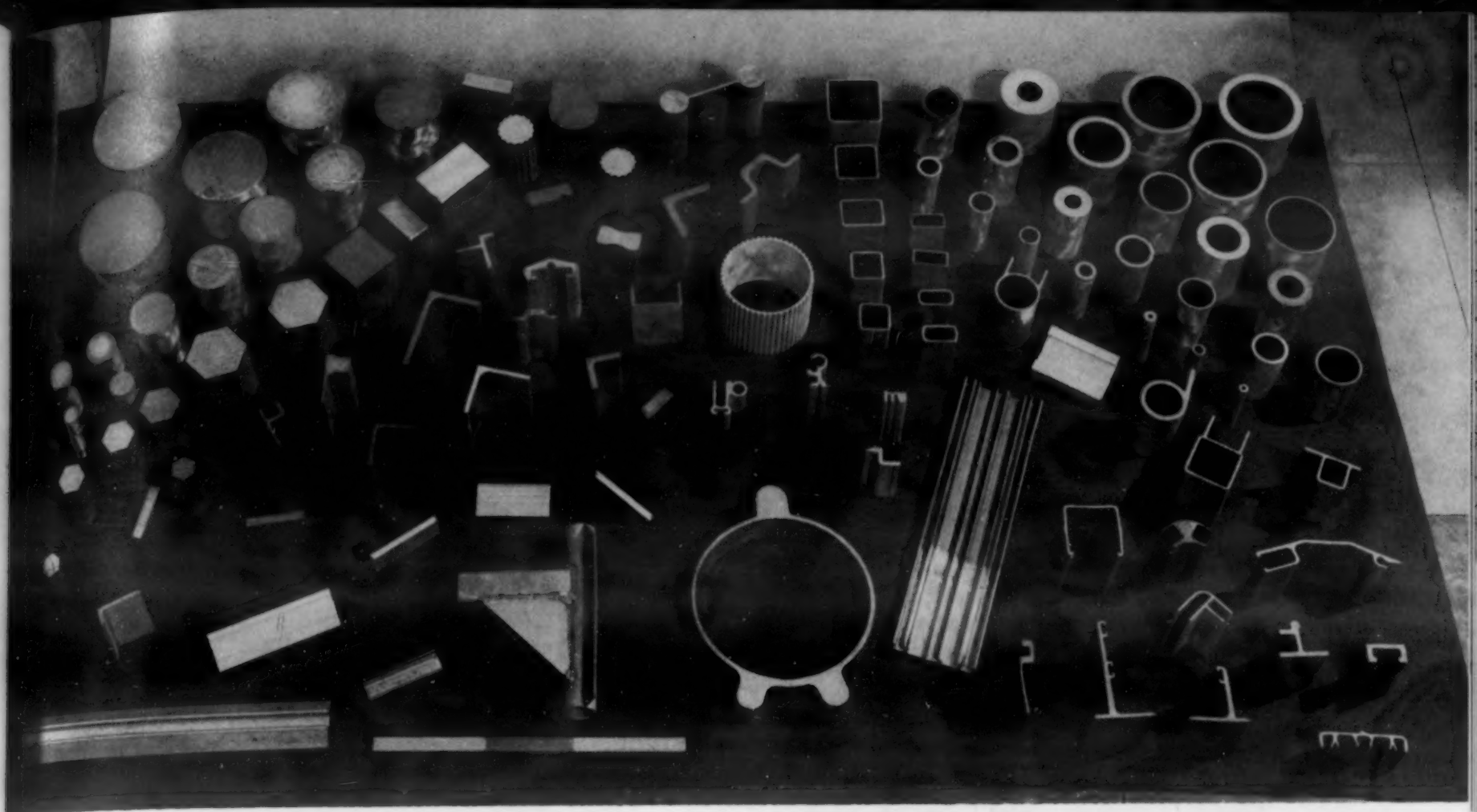


Fig. 1—Typical examples of magnesium alloy extrusions including bars, tubes and special shapes, a large proportion of which are available from stock dies. At lower center is an example of tubes welded to a gusset plate.

Advantages of Extrusions

1. Availability in extruded forms can be made to save much machine work, including some that would involve forming if sheet were to be used instead. This applies to such products as the window cleaner, Fig. 2. Its handle portion is made from reeded tubing of ⅝ by 1-in. oblong section riveted to cast fittings set into the tube and forming an adjustable fastening. The reeding provides a decorative effect and, by using the long diameter of the tube in the plane in which pressure is applied, stiffness is attained with minimum weight.

The head of this tool is also extruded in such shape that two channels are provided, one for thick wetting felt and the other for a rubber squeeze. To prepare this part for use, it is merely cut off to length and one hole is drilled for the attaching screw. No forming die is required, yet the shape is such that stiffness is attained along with light weight. A molded rubber handle slipped over one end of one extruded portion completes the assembly.

2. For a magnesium ladder, the longitudinals are square extruded tubes with integral legs that form a channel into which 1-in. sq. extruded tube rungs are fitted and attached by a single aluminum rivet at each end. Both longitudinal and transverse tubes possess unusual stiffness and consequent resistance to deflection combined with light weight. Although 10 ft. long, the ladder weighs only 9 lb. and is amply strong and rigid. But the only machine work needed is to cut off and drill the tubes for rivets.

3. Magnesium extrusions possess extreme utility, of course, in building many metal structures in which light weight and rigidity must be secured, but they can, at the same time, include other useful features not attained so readily if at all in rolled products or those made from formed sheet. This becomes apparent from Fig. 3, which shows sections used in truck and bus bodies and some for use in aircraft cargo carriers.

At the top of Fig. 3 is a section of a truck body panel made from aluminum covered plywood joined to magnesium extrusions of modified I-beam or T shape. To form this panel, the plywood is cut away along the edge and the metal is flanged back at right angles so that, at assembly, a pair of flanges is pressed into the deep slot produced (as extruded) in the

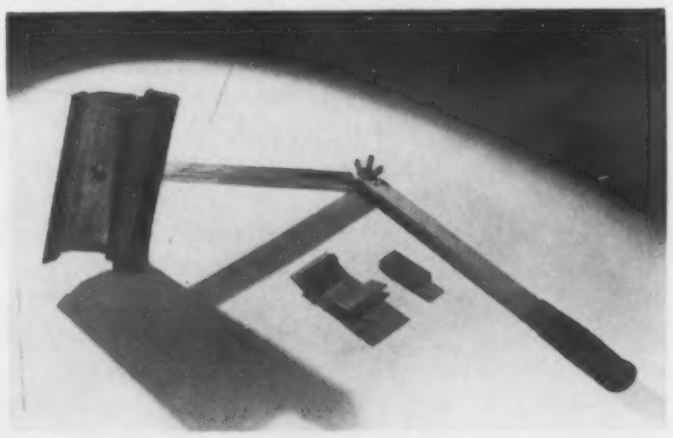


Fig. 2—A window cleaner made largely from extrusions. Light weight and convenience plus ability to clean all window surfaces without getting onto sills are sales-promoting features. Short lengths of the extrusions used are shown in foreground.

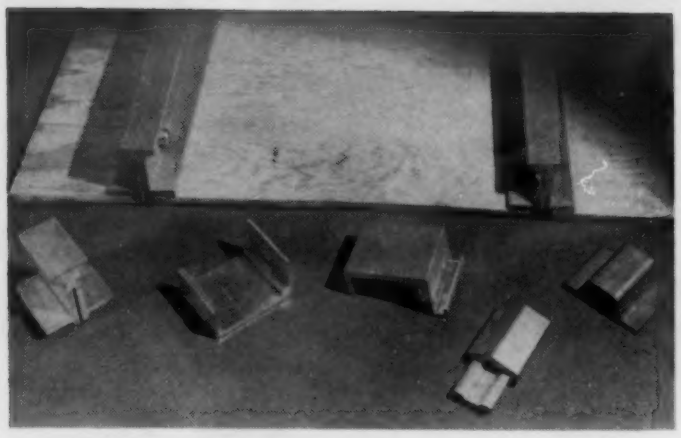


Fig. 3—Truck body panel (top) of metal-covered plywood joined by a special extruded magnesium I-beam. Other sections used in truck bodies and in cargo aircraft are in the foreground.

I-beam. When in place, holes are drilled for bolts that clamp the panel flanges securely and, together with the I-beams, form a rigid but easily fabricated structure that is light, has water-tight joints, and is capable of withstanding abuse while giving long and trouble-free service.

Also shown in Fig. 3 are other extruded magnesium sections used for truck body and related purposes. One of these is a body top rail that has an integrally formed drip molding of channel section. Such a section not only avoids the cost of making and applying a separate drip molding but, being integral, cannot come loose or cause leaks that might develop in a jointed assembly. The telescoping channels in Fig. 3 are used as rail-and-slide combinations in aircraft affording strength with light weight in fastenings that prevent the shifting of cargo in transit.

4. In the nursery "Bathinette," Fig. 4 light-wall extruded magnesium tubes of square section are used for legs and crossbraces. These are merely capped at top ends and have a bolt pivot that also supports a shelf. Besides affording greater strength and stiffness than wooden parts of the same dimensions, the extrusions, which are given a satin-like finish, are more attractive than wood, will not split, swell or check as wood does and afford more sturdy fastenings. Although this product sells for considerably more than wooden equivalents, it is reported to outsell them where both types are displayed.

5. Bars and tubes of magnesium especially when made from ASTM alloy AZ61, have exceptional tonal qualities when set vibrating at frequencies within the auditory range. This has resulted in use for organ chimes, door chimes and musical instruments, such as zylophones in some of which magnesium has replaced aluminum. In such applications, the bar or tube is drilled at one or both ends for supporting cords and is cut, of course, to such length as will yield the required pitch. In portable instruments, the light weight adds a further advantage.

6. Among the large architectural uses of extrusions is that involved in making window sash and casements. Those produced entirely from aluminum, however, have the disadvantage that aluminum sliding in contact with the same metal has a tendency to scuff. To avoid this, some guiding elements, where sliding takes place, are now made from magnesium extrusions. Motion of aluminum against magnesium avoids scuffing.

7. Since magnesium is very easy to polish and readily takes a high luster, it can be used effectively where a high polish without plating is wanted. A buffed surface has high light and heat reflecting coefficients and does not discolor fabrics that come in contact with the surface. This non-smudging quality has led to the use of extruded magnesium tube in making bobbins for delicate textile fibres, Fig. 5. Extremely smooth surfaces avoid clinging of fine fibres, and abrasion against the surface does not discolor as is the case with some other metals.

8. For making some types of metal furniture, magnesium extrusions present the advantages of being easy to form and to weld besides being light in weight, attractive in appearance and so smooth as not to scuff or catch in fine fibres of hosiery or other garments. Chairs and bar stools are good examples of such construction. Most of the frames are made from extruded tube which is easily bent cold but has adequate stiffness to resist abuse and denting in service.

The under side of the chair and stool, Fig. 6, shows the chair using both welded and bolted joints and the latter only screw fastenings, the tubes being flattened where they cross in the center. In the stool, the hoops are made from flat extrusions. Furniture of this type is attractive partly because of the silvery satin-like finish of the magnesium, which is given a clear lacquer coating to protect against corrosion.

Welding of magnesium is readily done with torch, arc or resistance methods. Extruded rod or wire can be used in welding along with a suitable magnesium or aluminum flux. A reducing flame is advocated. Oxyhydrogen, oxyacetylene, natural or city gas flames can be used. Butt joints are used, the area to be welded being properly cleaned and plenty of flux applied to avoid burning. Flux must be removed thoroughly after welding by scrubbing in hot water, chrome pickle swab, or dip.

In electric arc welding, a tungsten electrode surrounded by a stream of helium or argon is preferred, the arc being short. D.C. welders of standard design are used with polarity reversed. Spot welding can be done on welders designed for aluminum, and even some intended for steel can be utilized. Less current and lower pressures than for aluminum are applied, but good surface cleaning is required for best results. Spots should be cleaned abrasively to remove copper pickup, as copper will cause corrosion.

Soldering can be done with high cadmium-zinc-tin or cadmium-zinc solders, used without flux, but soldering is not advocated if the application involves stress or corrosive conditions. Riveting is frequently done. 56-S aluminum rivets are preferred but galvanized steel is permissible if protected by a paint finish, provided that noncorrosive conditions apply. Rivets having a diameter three times the section thickness are the optimum choice. Various rivet heads are used but, for countersunk or dimpled heads, the included angle should be 120 deg. All rivets should be set in

Fig. 4—Bathinette in which the legs and crossbraces are square tubes extruded in magnesium alloy and given a satin finish. Good appearance, sturdiness and light-weight are sales assets.

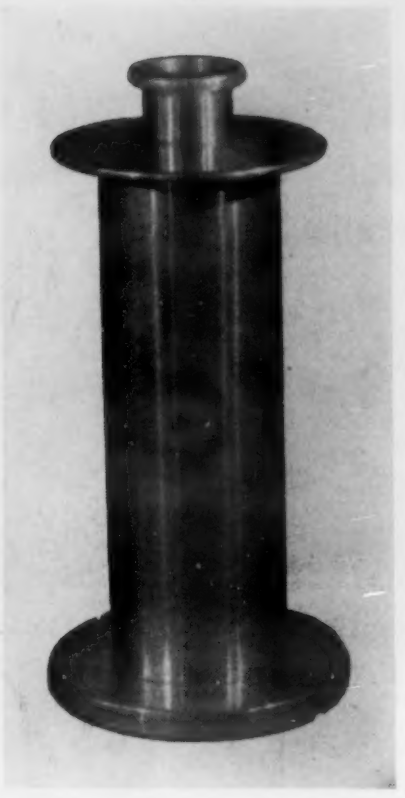


Fig. 5—Bobbin the barrel of which is produced from extruded and polished magnesium tube. The flanged ends are cast.

wet zinc chromate primer, and exposed joints should be well coated to avoid corrosion by entrapped moisture.

Magnesium is considered the easiest of all metals to machine and can be cut at speeds of 8,000 fpm. or higher if the machine used is capable of such speed. Heavy cuts can be taken and are recommended. The power required is said to approximate 0.2-hp. per cu. in. of metal removed per min., or about half that for soft brass and aluminum.

Machining is commonly done dry unless this results in too high a temperature in which case a flood of light mineral oil or fatty oils of low acid content can be used. Sulfonated oils are not recommended, as they result in chemical reactions with chips.

Where grinding is done or fine chips are produced, means for collecting the dust or chips, preferably drained of lubricant, should be provided, as fine chips are quite easily ignited. In all cases, machines and floors should be kept free of chips, as this reduces the chance of chip fires and prevents them from spreading should they occur.

Cutting tools should be kept sharp to minimize friction. Rake of 5 to 10 deg. and 10 to 25 deg. clearance is commonly recommended. Larger than common clearance angles are required on drills, taps, reamers and milling cutters, and saws should have few teeth per in. and plenty of side clearance to produce large chips and afford ample chip clearance so that frictional heat is minimized. Skip-tooth band saws are recommended, and fly cutters often give better results than ordinary milling cutters. Some tools designed for wood working can be used successfully on magnesium but, especially for long-run work, carbide or other tools that hold a sharp cutting edge well are recommended.

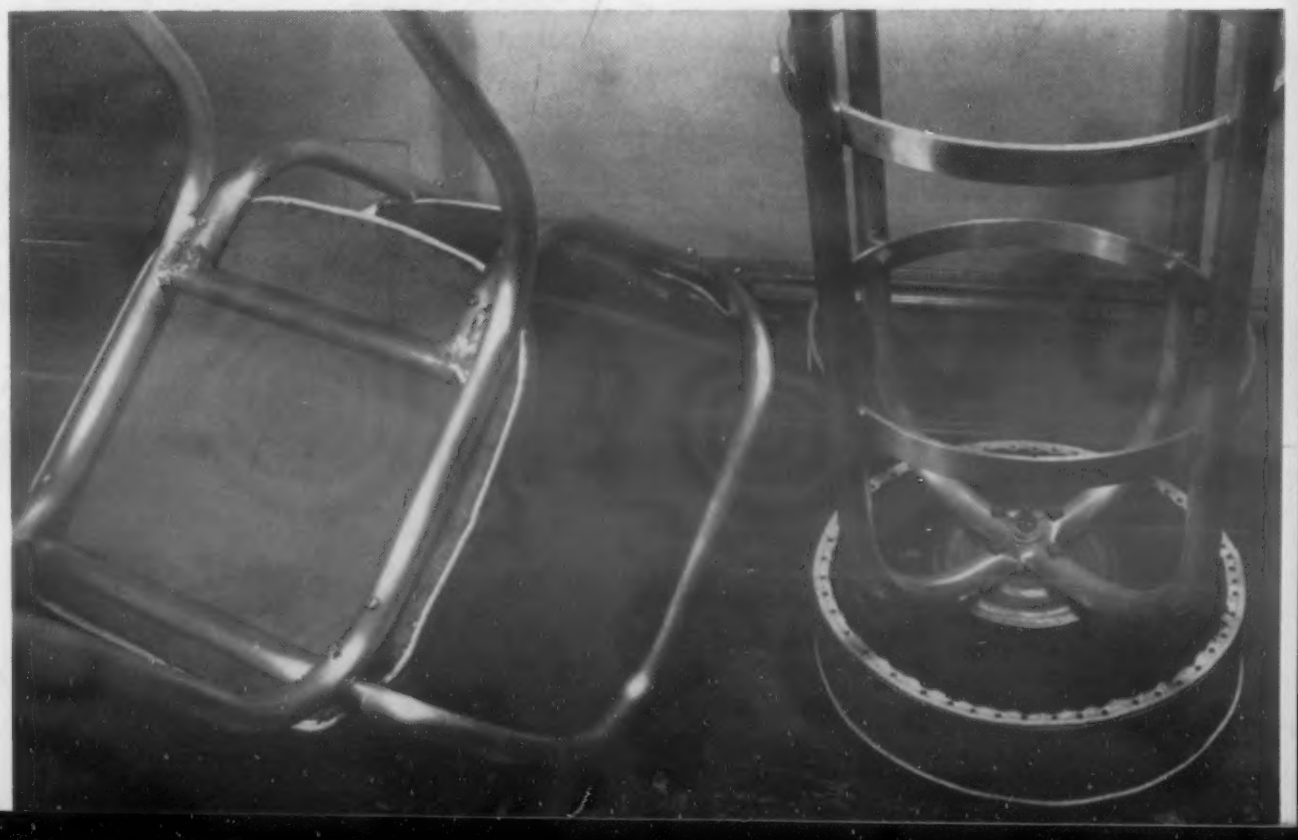


Fig. 6—Under side of the chair and stool illustrating how both welded and bolted joints are used.

The compact layout possible with pit type furnaces permit easy access to quench tanks and the tempering furnaces. (Courtesy: Lindberg Engineering Co.)

Foundries and Forge Shops Reduce Heat Treating Costs

by KENNETH ROSE, *Engineering Editor,* MATERIALS & METHODS

THE PRINCIPAL PURPOSE of a foundry is to make castings. The foundry superintendent, when thinking of heating or furnaces, will probably think first of his melting equipment, and properly so. In steel foundries, however, the ordinary heat treating procedures of annealing, normalizing, and sometimes quenching and drawing, are a sufficiently important part of the production of finished castings to warrant a cost-conscious study of the equipment used.

Because the heat treatment of its castings is somewhat apart from the foundry's principal endeavors, there is a strong tendency to give less consideration to the type of equipment used for heat treating than it deserves. The foundry may pride itself upon its up-to-date melting furnaces, but almost any sort of box furnace is considered good enough for such a supplementary task as heat treating.

Cost studies, made by three Milwaukee plants, show that when supplemental heating is required it is important to install modern heat treating furnaces.

Substantial savings are possible by replacing old-fashioned equipment by modern, high production types in many foundries. Even when heat treating is a minor part of the production picture, the investment is self-liquidating because of the considerably higher efficiency of the newer furnaces designed especially for heat treating.

Three important plants in Milwaukee have recently completed comprehensive studies of the gains made by installation of high production furnaces. In each case the furnace has been in operation for over a year, so that the work handled included a representative cross-section of the parts heat treated by the company under normal conditions.

Annealing Gray Iron Castings

At Wisconsin Motors Corp., producers of annealed gray iron castings, six oil-fired box furnaces had been in use for annealing the large output of gray iron cast-

Considerable hand labor is required in loading and unloading box type furnaces. (Courtesy: Wisconsin Motors Corp.)

Improved facilities for handling the furnace charges is a prime factor in the economy of pit type furnaces. (Courtesy: Lindberg Engineering Co.)

ings from its foundry, and for heat treating some of its forgings. Because of the large quantity of work to be handled, it was necessary to send some of it outside the plant to be treated. The six box furnaces were large, and the floor space occupied by furnaces and charging and discharging areas could be reduced, it was felt. Costs came under scrutiny also, and after careful study it was decided to install two high production pit type furnaces to replace the old style equipment.

To obtain accurate data upon which to base a comparison of performance and costs, careful records were kept of quantity of work, fuel, labor, and other factors over a representative two-day period with the box furnaces. After installation of the new furnaces, similar records were made for a like period, with work of the same sort being treated in the furnaces.

Some of the facts learned:

Operation

	Vol. of Work Handled	Avg. Wt. of Charge	Avg. Temp.	Total Heats	Avg. Heating Time	Fuel Cost per Ton
New Furnaces	81,606 lb.	2,548 lb.	1546 F	32	2 hr., 31 min.	$1.60
Old Furnaces	25,824 lb.	2,347 lb.	1223 F	11	6 hr., 2 min.	$1.92

Labor

	Avg. Loading Time	Avg. Unloading Time	Total Labor Required	Lb. per Man-Hour
New Furnaces	35.4 man-min.	20.3 man-min.	96 man-hour	850
Old Furnaces	30.6 man-min.	29 man-min.	57 man-hour	440

The floor space required for the old furnaces was 1400 sq. ft., while the new furnaces were installed in 780 sq. ft. With the new furnaces more than five times as much work is being handled per square foot of floor space as before — 104 lb. as against 18½ lb. with the old style furnaces.

The quantity of work turned out during the two-day periods showed a gain of 190% with the new furnaces. The higher and more uniform heat obtainable, with a consequent decrease in the time for each heat and increase in the number of heats, was the principal factor in this increased production.

Other important economies were those shown by the decrease in the amount of labor, due to better design and floor layout. Labor required per pound of pieces heat treated was nearly halved.

Heat-Treated Steel Castings

Pelton Steel Castings Co., also of Milwaukee, produces steel castings of carbon content ranging from low carbon to about 0.55% carbon. Heat treating consists of annealing, normalizing, quenching, and drawing, or whatever treatment the customer may specify. Heat-treating is, therefore, an important part of the production scheme and the heat-treat department must have not only adequate capacity but flexibility as well.

A large car-bottom furnace, oil fired, had been in use, but with the need for flexibility in operations it was thought desirable to install additional equipment. The car-bottom furnace has been kept in service, as it is necessary for handling large or irregular castings, but most of the general run of production has been diverted to the newer pit type high production furnace. The monthly tonnage total of both furnaces is the same — about 200 tons — but the newer furnace occupies only about one-fourth the floor space of the car-bottom type.

Some comparative data assembled upon the two furnaces is as follows:

	Avg. Load	Heating Time	Heats per Day	Floor Space Required
New Furnace	5000 lb.	5 hr.	4	400 sq. ft.
Furnace Previously Installed	13,000 lb.	11 hr., 55 min.	1½	1530 sq. ft.

The new furnace uses only a single burner, whereas the car-bottom furnace uses ten. About 1 hr. is required to light the burners in the latter furnace, but the burner for the new installation can be lighted in 10 min. The difference in the number of burners also makes for lower maintenance with the new furnace.

A sharp limitation of these smaller, high production, pit type furnaces is that indicated by practice at Pelton Co. Quite substantial economies can be achieved in handling small work, but the foundry that frequently or even occasionally must anneal or normalize a large casting must either keep a furnace of suitable size as a standby, or must send the large work to an outside processor.

Heat-Treated Small Forgings

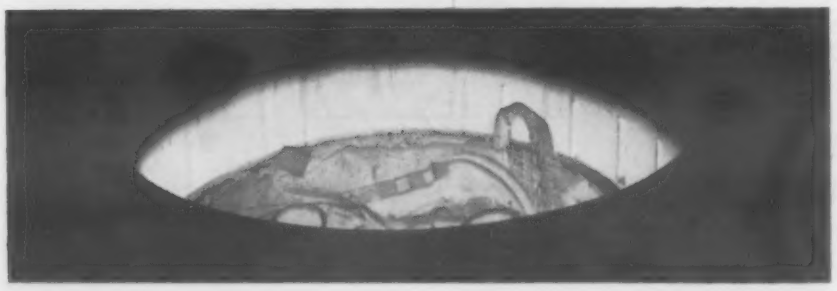
A third Milwaukee concern, Unit Drop Forge Div. of Fuller Manufacturing Co., does normalizing, hardening, tempering, and stress relieving of small steel forgings, such as crank shafts, levers, pinions and rollers. They present much the same problem to the heat treat department as would steel castings of the same general size. Four high production furnaces were installed, and studies have been made to check performance.

Normalizing is done at 1650 to 1750 F, hardening from 1550 to 1650 F, tempering at 1150 to 1250 F, and stress relieving at 1050 F. Performance data was obtained on a total of 42 heats, including all heat treating operations. Tests extended over a four-day period.

The total weight of parts in the heats included in the survey was 183,567 lb. The average weight of each charge was 4,371 lb. The average time required for four men to load the rack was 4⅝ min., or 18½ man-min. total. Charging the furnace after loading the rack required only a little more than 1⅝ min. with four men, or 6¾ man-min. Removing the charge required the same time, 6¾ man-min., and unloading the rack required 18 man-min. Heating time for a charge was 3 hr., 43 min.

Each furnace handled a total of 26,226 lb. of parts per day. The total labor averaged out to 96 man-hr. per 24-hr. day, using four furnaces, or 1092 lb. of work per man-hr.

In each of the three plants, each handling a different kind of work, substantial savings in operating costs, direct labor, time and floor space were made by the shift to high production furnaces for heat treating small to medium-sized castings and similar parts. The savings indicated in the reports from each plant would seem to prove that foundries having heat treating of this sort to do might make similar cost reductions by adopting modern heat treating furnaces, even though heat treating is not their main line.



Ample insulation and sealed covers insure uniform heat throughout the modern pit type furnace.

The internal involute splines in this universal joint are broached, while the external splines are shaved. This is a high precision job as no backlash is permissible.

The Broachability of Materials

by **HARRY GOTBERG,** *Chief Engineer, Colonial Broach Co.*

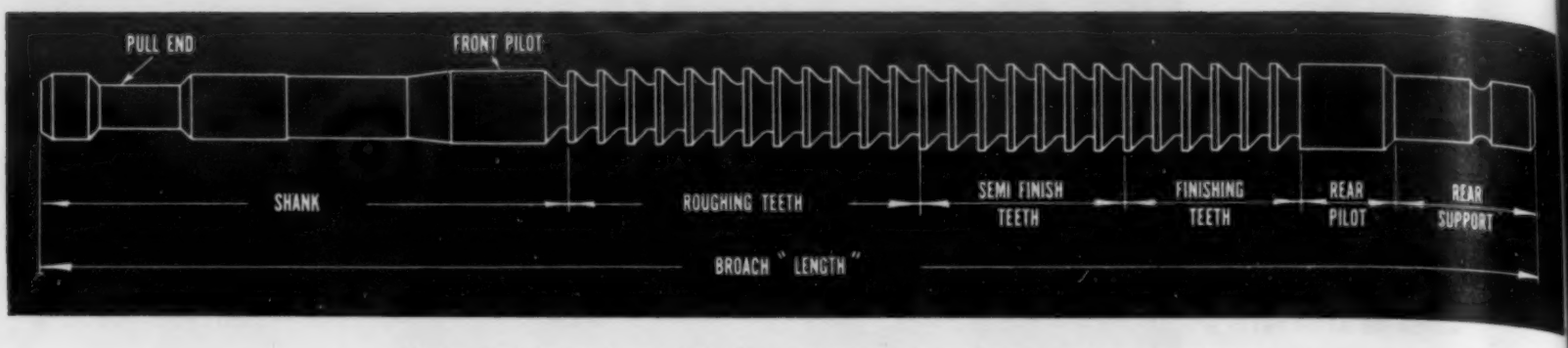
PRIME REASON FOR THE GROWING POPULARITY of broaching today is that it is one of the fastest methods of removing metal, either internally or externally. This is true whether the material being machined is steel, iron, nonferrous or nonmetallic. In addition, many operations are performed today with a single pass of a broach that would require two or more operations by other machining methods.

The reason for the high speed and accuracy of metal removal of which broaching is capable lies in the fact that the tool is composed of a large number of individual cutting teeth. Each of these teeth does its predetermined share of the work—no more, no less. Each successive tooth on a broach cuts just a little deeper than the one immediately ahead of it. In other words, both the necessary feed and depth of cut are built into the broach itself.

Although most engineering materials are well suited to broaching, their characteristics, including ductility, influence many operational factors.

Because of this design, the broach is able to rough, semi-finish and finish holes or surfaces, regular or irregular shapes, in a single pass. The first group of teeth do the roughing. The center group does the semi-finishing. The last group of teeth finish the job. The step per tooth is usually larger in the roughing sections than in the finishing section.

While the roughing teeth do not necessarily have the same general form as do the finishing teeth, the finishing teeth, of course, must be exact replicas of the shape which the tool is to generate. Roughing teeth, on the other hand, may be designed so as to distribute most economically and effectively the job of removing surplus metal before finish broaching. Thus, the shape of roughing teeth may approach more



Parts of a broach and broach terminology are shown on this drawing.

closely the *initial* contour of the work piece rather than the final desired form.

Average tool life and life per grind of a broach is comparatively long, due to the large number of cutting teeth in each broach and the small amount of work that each tooth performs in an average single pass.

Effect of Materials on Broaching

Any material—metallic or nonmetallic—that can be *machined* can be broached. Certain physical characteristics of the material being broached, however, directly affect the design of the broach, especially with respect to speed, face angles, clearances, etc. In general, the higher the machinability, the more easily and economically the material can be broached.

Hardness and Strength—In steels, machinability generally bears a close relationship to hardness, although other factors also influence machinability. The best range is between 25 and 35 Rockwell C. Harder steels can be broached, but sometimes offer special problems as to tool life and lubrication. Steels softer than Rockwell 25 C can be broached satisfactorily. Rather soft steels, however, may be somewhat difficult to broach inasmuch as they tend to tear, throw up burrs, or tend to stick to the broach's cutting teeth. Work having a high *surface* hardness—such as that produced by previous work hardening or a crust of scale—requires that the first tooth of the broach should cut beneath the scale or hard surface layer.

Different materials of varying hardnesses sometimes require varying cutting speeds to produce the desired combination of fine finish, long tool life, and maximum production. The softer nonferrous metals theoretically *can* be broached at much higher speeds than can the general run of steels. However, it will be well to remember in this connection that the speed of the broaching operation is pretty well limited by the speed of the machines. At present, a cutting speed of about 30 ft. per min. is normally the economical top speed for modern hydraulic broaching machines. A higher *return* speed keeps the idle time between actual broaching cuts down to a bare minimum. Loading frequently is during the return stroke of the broach.

Hardness and strength of the material broached also influences the required *broach strength.* Assurance of adequate strength is one of the most important considerations in broach design. In this connection, presence of chilled sections and hard spots in the work piece must be taken into consideration, since these can easily cause considerable overloads on the tool during the broaching operation.

In the case of "pull broaches," strength is determined by the area of the smallest cross-section (usually at the root of the first roughing tooth, or at the pull end). In "push broaches," the "weakest" section is usually the middle of the broach since in this case the tendency is for the broach to buckle in the center.

In general, allowable maximum pull in pounds per square inch for a high-speed steel broach can be calculated from the formula:

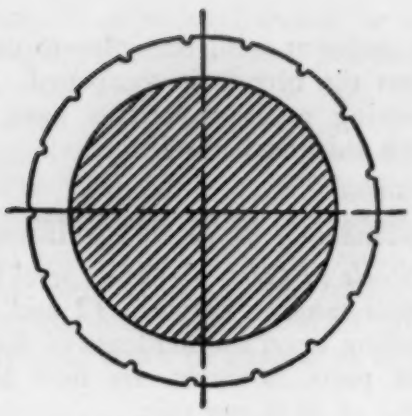
$$\text{Allowable pull} = A \times K$$

where A is the area of the smallest diameter of broach (usually root diameter at the first tooth), and K is any figure below the tensile strength of the broach material, depending upon the safety factor desired. It is always desirable to use a safety factor to prevent broach damage in case of sudden overloads due to chilled sections, hard spots, or other inequalities in the strength and hardness of the material being

Table No. 1

Rough Approximation of Relative Power Required to Broach Metals

Metal	*Relative Power Required (1 = Lowest)*
Magnesium Alloys	1.0
Aluminum Alloys	1.2
Brass	5.0
Cast Iron; Bronze	5.0
Malleable Iron	7.5
Phosphorus Bronze	7.5
Manganese Bronze	10.0
Mild Steels	11.0
Alloy Steels	12.0
Hot Rolled Steel	12.5
Forging Steels	14.0
Nickel Alloys	15.0
Nickel Steels	15.0



In this sketch is shown the method of "nicking" broach teeth to form chip breakers.

broached. Thus, if broach tensile strength is 120,000 lb. per sq. in. and a safety factor of 100% is desired, then K = 60,000.

The degree of hardness of the material also influences the permissible cut per tooth. On the harder metals, it is customary to take a relatively fine *finishing* cut. On the softer nonferrous metals a relatively heavy finishing cut can often be used to produce fine finish. It should be remembered, however, that too large a step will tend to overload the broach tooth regardless of the material being broached. Again, too light a cut tends to interfere with free cutting action, increasing the tendency to glaze, gall, or tear the broached surface. Smaller steps can be used for finishing teeth than for the roughing teeth.

Ductility—The ductility of a material has a considerable influence on the desirable face angle (hook or rake) of the broach teeth. In general, this angle decreases with decreasing ductility. Brittle materials, therefore, call for quite small angles.

Chip Forming Characteristics—A broach must—by its very nature—usually carry all of the chips with it until it comes out of the cut. This means that enough space has to be provided between the individual teeth to carry the chips without crowding. If this is not done, there is a chance of dulling and even breaking the tool; roughing up the work surface and tearing it.

The chip characteristics of the material being broached—*i.e.,* whether short, brittle chips; fairly long chips; or long, tough, stringy turnings are produced—determines whether or not some form of chip breaker is needed. It should be remembered that chips produced by a broach are not unlike chips formed by single point tools.

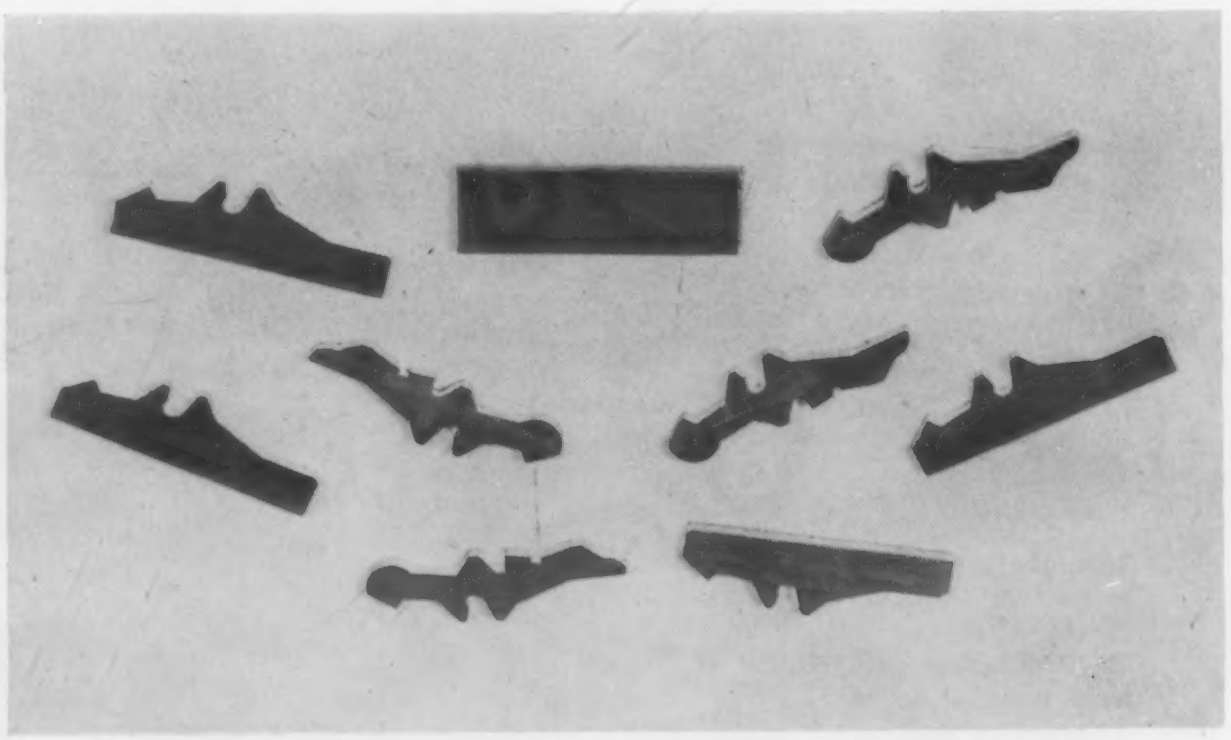
In general, the long or continuous type of chips are harder to control than short chips. This is especially true in round hole broaching where a continuous ring would form if the chip were not broken. This is usually taken care of by having the teeth "nicked." Chip breakers of this nature are staggered on successive teeth.

Pitch (or tooth spacing) does not usually depend on the material broached although less pitch is permissible when machining the short chip or "crumbly" materials than when machining the long chip materials, since less chip room is required in the former instance. However, pitch has an important bearing on the length of cut the broach can handle on a given machine and on the thickness of the chip which the broach can remove effectively. It also determines the number of teeth in contact with the work at one time.

A formula frequently used to determine the permissible length of cut is:

$$\text{Pitch} = 0.35 \times \sqrt{\text{length of cut}}$$

Material being broached has little effect on the clearance angles of the broach. Normally, the entire thickness of each tooth is backed off at a slight angle. Sometimes different angles are used on the roughing teeth than on the finishing teeth. It is desirable, of course, to hold clearance angles down to a minimum



Copper circuit breaker parts are produced from slugs by surface broaching. Several parts are broached at one time through stacking.

Die cast carburetor bodies are broached. In this operation the pads are broached. In a second operation, the broaches have carbide teeth to hold size accurately.

—consistent with the job—to cut down loss of size when the broach is sharpened. For this reason, the finishing teeth sometimes have a portion of their tooth thickness unrelieved.

Broachability of Various Materials

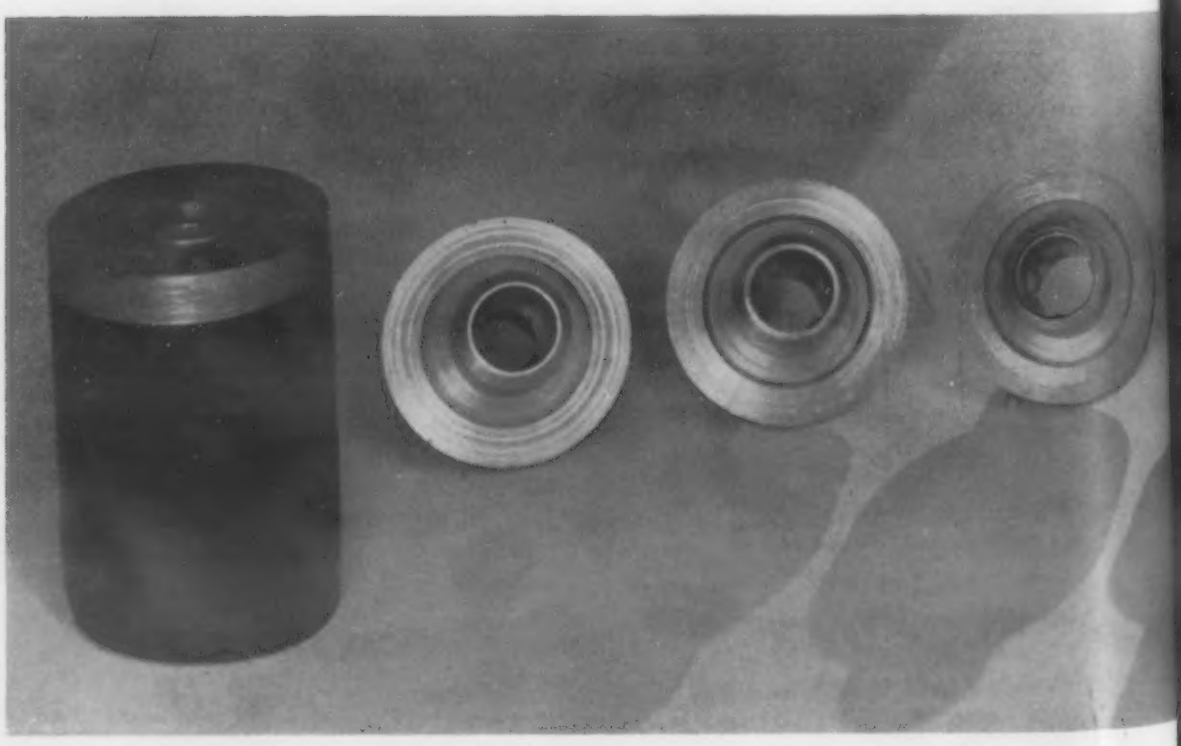
Steels in General—Most steel jobs are broached at speeds ranging between 12 and 24 ft. per min., depending upon the hardness of the metal. Many small steel parts, however, are now being broached at a speed of 30 ft. per min.

A free cutting steel will allow a greater step (cut per tooth) than will a hard or tough steel. However, a step of 0.0005 in. on a broach diameter is a practical minimum. "Hook" or "rake" angles also vary with the material being cut. The range lies between 15 and 20 deg. for the soft steels and 8 to 12 deg. for the hard steels. Clearances of 2 to 3 deg. on the roughing teeth; 1 deg. on the semi-finish teeth; and ½ deg. on the finishing teeth will give good results when broaching steel.

When broaching steels, broach teeth should be "nicked" to break up the chips, as already mentioned. These "chip breakers" should be staggered on successive teeth.

Stainless Steels—Most modern broaches will handle stainless steels having hardnesses running as high as 35 Rockwell C. Broaches have cut stainless stock even harder than this, but in most cases the cost is prohibitive since the broach tends to dull fairly rapidly, reducing pieces produced between grinds.

Cutting speeds range between 8 ft. per min. for the hard stainless steels to as high as 20 and even 25 ft. per min. for the more "free machining" types. Approximate cut per tooth (round broaches) will run from 0.001 to 0.005 in. This range will handle practically all types of stainless. Broaches with hook or face angles between 12 and 18 deg. usually give



This photograph shows progressive steps in the slotting of a pump rotor. The work is done on a Colonial universal horizontal broaching machine.

good results. The amount of back-off should be held to a minimum, of course. A 2-deg. angle is preferable, and the clearance should never exceed 5 deg. Chip breakers should be used.

Cast and Malleable Irons—Normally, these materials can be broached at 30 ft. per min., the maximum speed of modern hydraulically-operated broaching machines of up to 15 and 20 tons capacity. Since the speed of the machine depends upon the volume of oil that can be pumped, maximum speed of larger machines is generally held down to around 15 ft. per min.

Cast iron generally permits use of a greater step or cut per tooth than even a free cutting steel, since the power constant for cast iron is less than that for steel. Brittle materials such as cast iron call for small face angles, usually around 6 to 8 deg. Clearance of back-off angles are the same as for the general run of steels. Usually, a shorter pitch is permissible when machining cast irons than when broaching steel, since less chip room is usually required.

Brasses and Bronzes—In general, the commercial bronzes and brasses are broached at a cutting speed of 30 ft. per min. It is usually possible to take a slightly heavier step or cut per tooth on brasses and bronzes than on steel. Too heavy a step, however, will tend to overload the broach.

Face or hook angle of broaches for use on brasses and bronzes usually range from 0 up to 10 deg. and even higher, increasing with the ductility of the metal being broached. Brittle brasses call for smaller angles, running from 5 to −5 deg.

Roughing teeth on broaches for machining brasses and bronzes usually have a 2-deg. clearance; 1-deg. clearance on the semi-finishing teeth; and ½-deg. clearance on the finishing teeth.

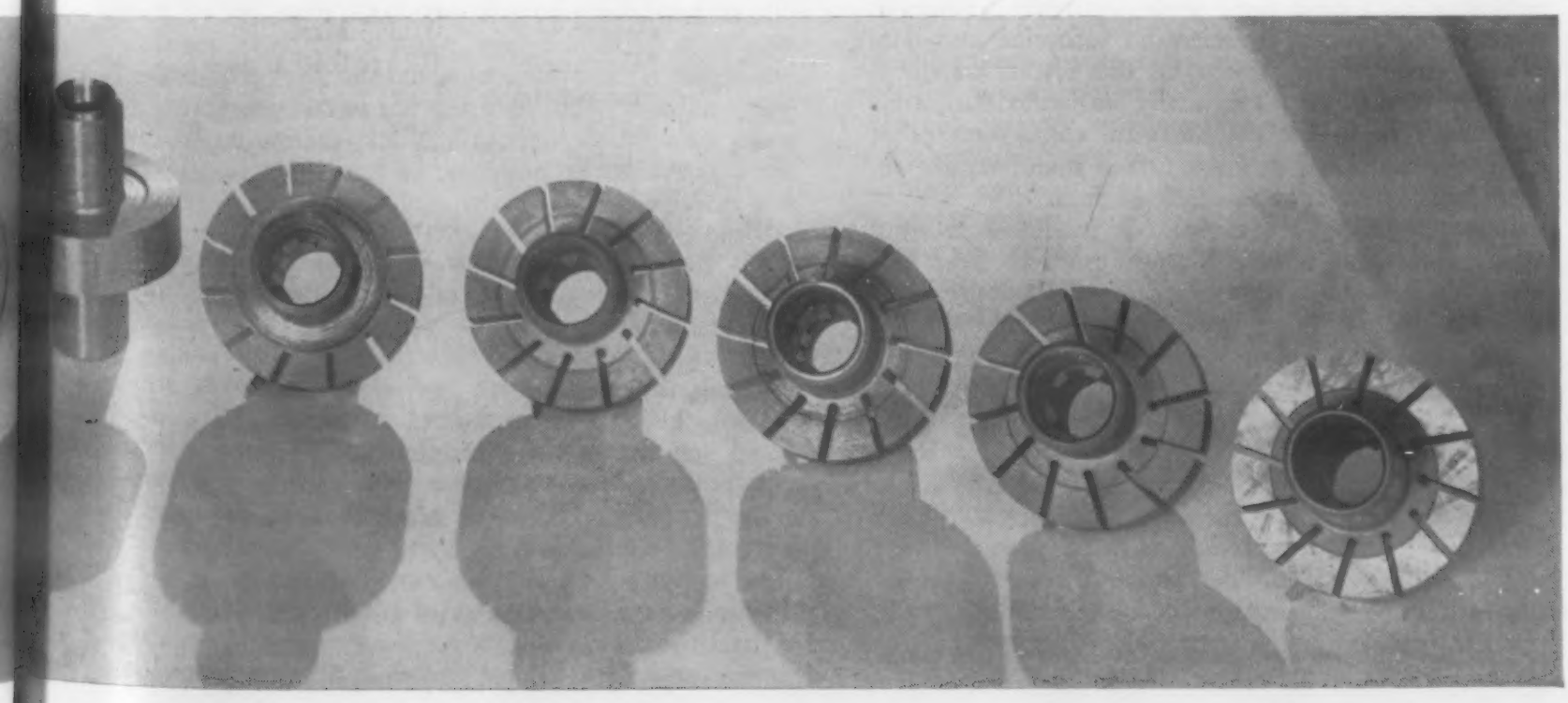
Need for some form of chip breaker is indicated when broaching those brasses and bronzes which give a long or continuous chip. This is usually taken care of by "nicking" the teeth.

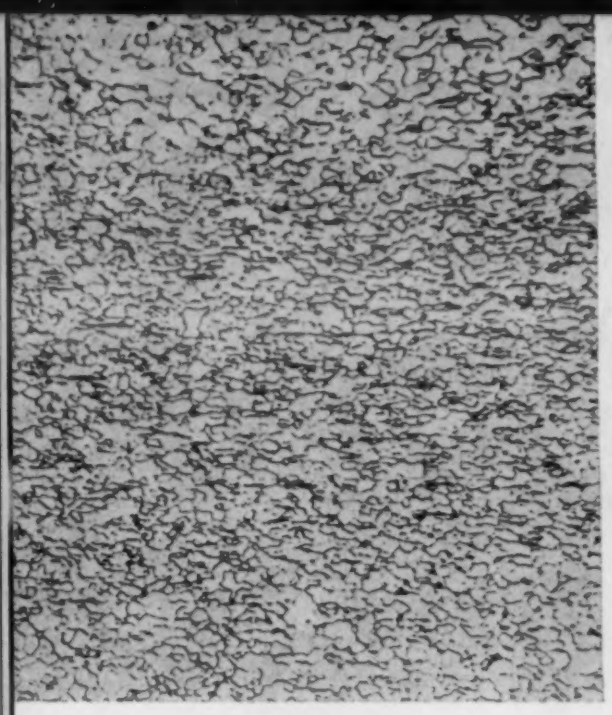
Aluminum and Magnesium—Aluminum and magnesium could probably be broached at speeds as high as 80 ft. per min. This speed, as has been pointed out, is economically not feasible at the present time. Speeds, therefore, are top speeds of which the machine is capable. Standard broaches can be used for these alloys, although even better results will be obtained if slight alterations are made in their design. A hook or rake angle of 10 to 15 deg., with relief angles between 1 and 3 deg. may be found advisable.

For magnesium, larger chip spaces than those for other metals are desirable. Heavier cuts can be taken, with even the finishing teeth removing about 0.002 in. each. If trouble is experienced in maintaining proper tolerances, it is suggested that the size of the finishing cut be *increased* rather than decreased. An extremely fine finish can be obtained on these metals with a relatively heavy finishing cut.

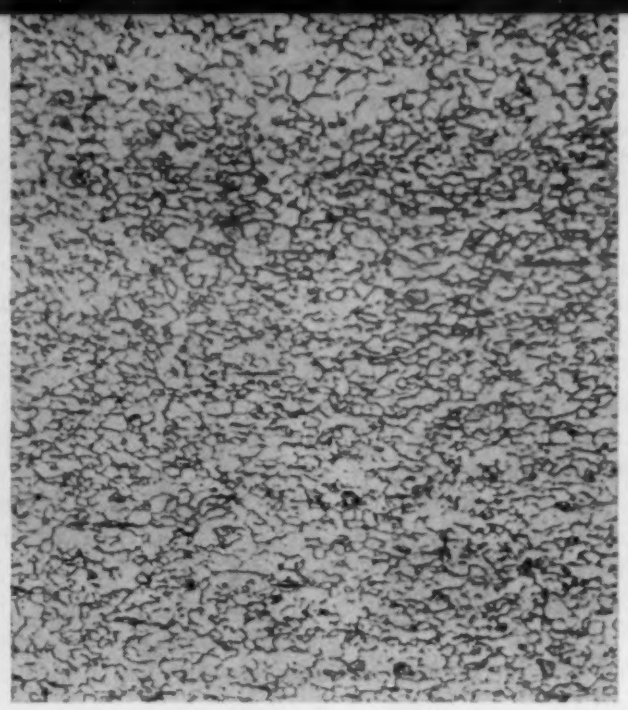
Plastics—Both the hard vulcanized fiber and the laminated phenolic plastics can be broached in either the horizontal or the vertical types of broaching machines. Broach design is generally the same as for broaching brass, although the material may require modifications in broach design.

There are other factors which affect broach design and the broaching operation than those covered in this article. For instance, choice of machine—as to type, capacity, speed, etc.—is of utmost importance. So, too, is the design of the broaching fixture employed. Successful broach use also demands the correct handling and storing of broaches in the shop as well as in the inter-departmental transportation of these tools between the sharpening equipment and the broaching machine. In addition, proper resharpening of the broaches will not only prolong the life of the tool but will also maintain output, both as to quantity of parts produced and as to their conformity to specified dimensions and finish.

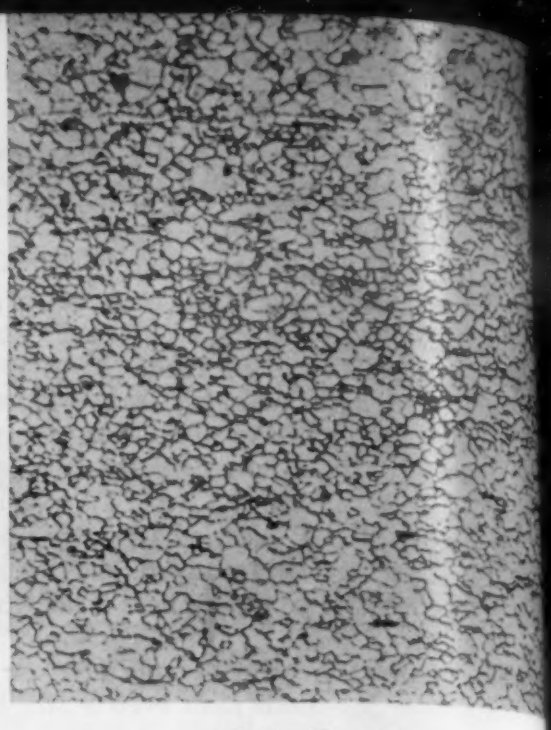




Grain Size 384



Grain Size 192



Grain Size 180

Proper Selection of Steel Simplifies Deep-Drawing

by G. B. NISBET, *Contact Metallurgist, Lackawanna Plant, Bethlehem Steel Co.*

PLASTIC DEFORMATION OF METALS is an ancient art, which, until recent years, progressed mainly by trial and error methods, the results of which were kept as trade secrets. During the past decade, much of this secrecy has been lifted and considerable published data have been made available. However, there is still a lack of scientific formulae and data suitable for use in predicting the results of deep-drawing operations. The many variables that arise from changes in the metallurgical characteristics of the sheet stock and changes in the materials are responsible for much of this lack of data.

In normal times the automobile manufacturers are the biggest users of large stampings. This field presents the greatest difficulties in meeting the creations of the designers. Because of the ever increasing use of functional design, steel mills and stamping plants alike must strive incessantly to better previous records in producing involved and intricate shapes from metal sheets.

In 1941 fenders and body parts were difficult to make. When 1942 models were released, misgivings were the rule, but through close cooperation the problems were solved. Yet, looking at some of the illustrations now appearing in newspapers and trade journals, it seems as if the deep-drawing problems of the automotive industry are just beginning.

Analyses of Deep Drawing Steels

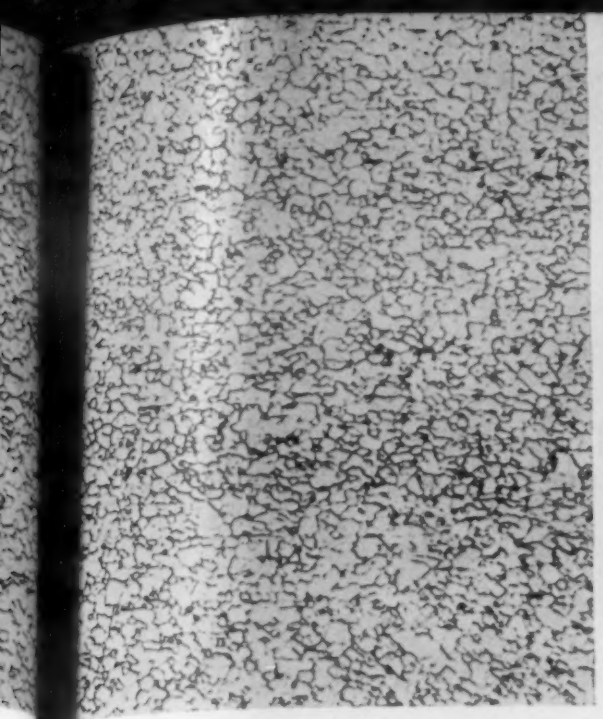
The steel most commonly used for deep-drawn sheets is rimmed steel of approximately the following analysis:

Carbon	0.08% Max.
Manganese	0.25 to 0.40%
Phosphorus	Low
Sulfur	Low
Silicon	Trace

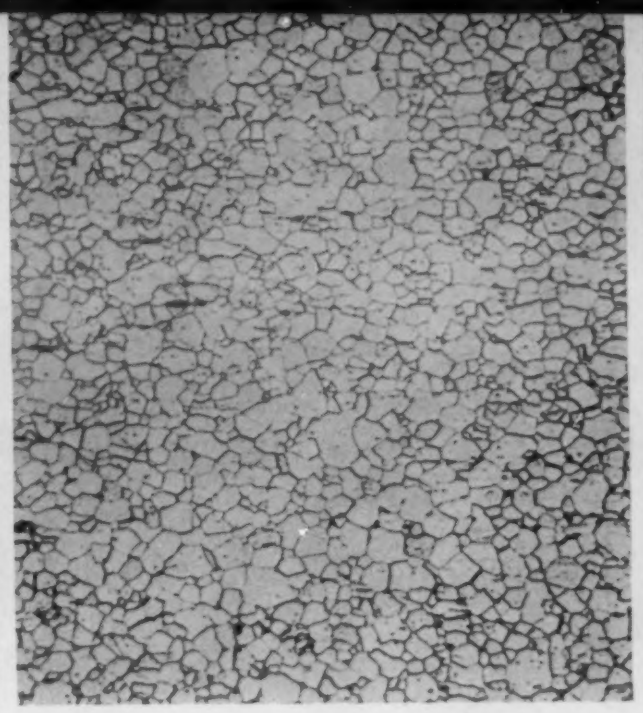
All other elements are kept as low as possible. Tin is particularly harmful in drawing operations because of its hardening effect. Combinations of small amounts of other metals such as chromium, copper and nickel are also objectionable.

Both basic open hearth and Bessemer steels are used for sheets. Bessemer steel is usually only considered for flat work or angle bending, never for deep-drawing. Even with the chemical analysis and steel type given, choice of selected slabs from an ingot may be necessary for extra difficult stampings.

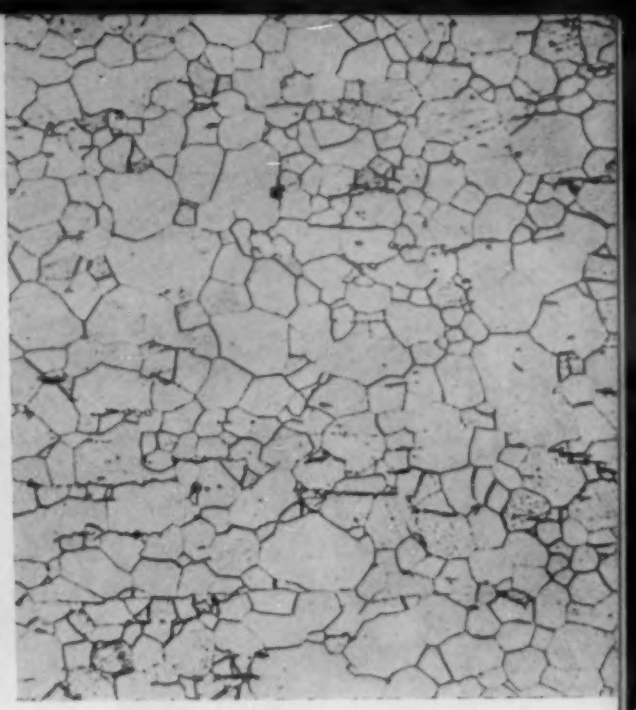
The refrigerator and stove manufacturers are probably the second largest users of stampings. Many of the parts for these products are enameled and require a sheet especially made for porcelain or glass enamel-



Grain Size 145



Grain Size 95



Grain Size 48

The grain size of sheet steel, which is controlled by the melting and rolling practice, determines its suitability for the production of various types of deep drawn parts. (100 X Nital etch)

ing. This sheet differs somewhat from the automotive sheet both in analysis and surface finish. It has lower carbon and manganese content, and all other elements must be kept to a minimum. One reason for keeping the content of these elements so low is that, in the early days, the frit or glass used in the enamels required a high temperature for proper fusion. Thus, if the sheet should pass through the critical point before the frit were fully fused, a detrimental expansion and contraction would take place and cause buckling or warping of the stamping. Stresses in the stamping, which are released at the enameling temperature, may also cause warpage.

The surface required is dull or slightly rough. It is obtained from etched rolls and is very helpful in giving good enamel adherence.

In recent years, some of the stampings for stove and refrigerator assemblies have taken on the aspect of deep draws. With sheets of extra low analysis it it difficult to make these draws because the sheets are too soft and weak. They neck down and pull apart before the desired depth of draw has been reached. Sheets with nearly the same chemical composition as automotive sheets, made with very careful mill manipulation to give inherent flatness and proper surface, have been found very satisfactory, especially since the frit manufacturers have adopted

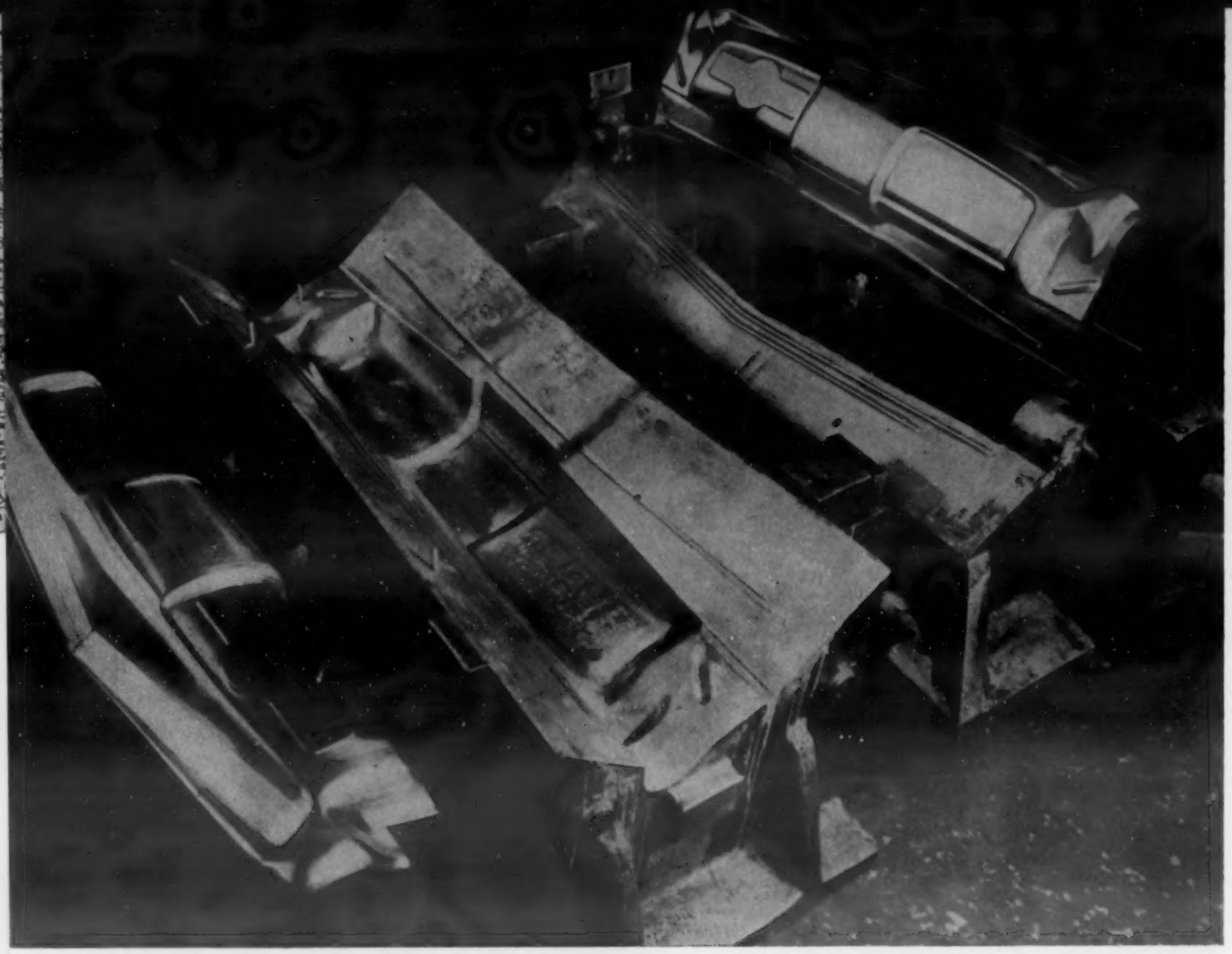
Successful production of deep drawn steel parts depends not only on a careful choice of sheet stock, but also on the proper die materials.

lower-temperature frits which lend themselves very well for use in connection with steel of this analysis.

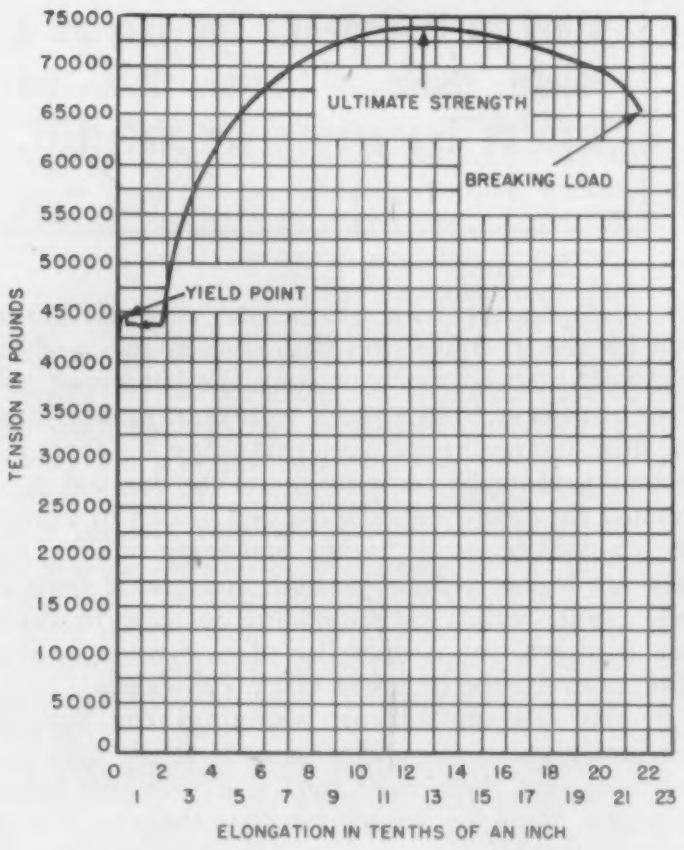
In cold-reduced sheets or strip age hardening may occur anywhere from a week to several months after the final tempering or skin pass. Age hardening is becoming generally recognized and the demand is increasing for sheets that will not age harden in storage. The changes occurring in age hardening of sheet and strip are higher tensile strength and elastic limit or yield point, with a corresponding increase in Rockwell hardness, and a lowering of elongation or ductility, as evidenced by lower Olsen cup values.

In the case of difficult stampings the supplier sometimes stored the sheets or coils at the skin pass mill and gave them their final skin pass just before shipment, with the stipulation that they be used as early as possible after receipt. However, this was no real answer to the problem.

This article is based on a talk recently presented by Mr. Nisbet before the Detroit district, Pressed Metal Institute.



Proper choice of die materials depends upon the type of part to be made, the kind of steel to be used and the quantity of parts required.



The double yield point found in low carbon sheet steels is the basic cause of stretcher strains.

Physical Properties of Deep-Drawing Steels

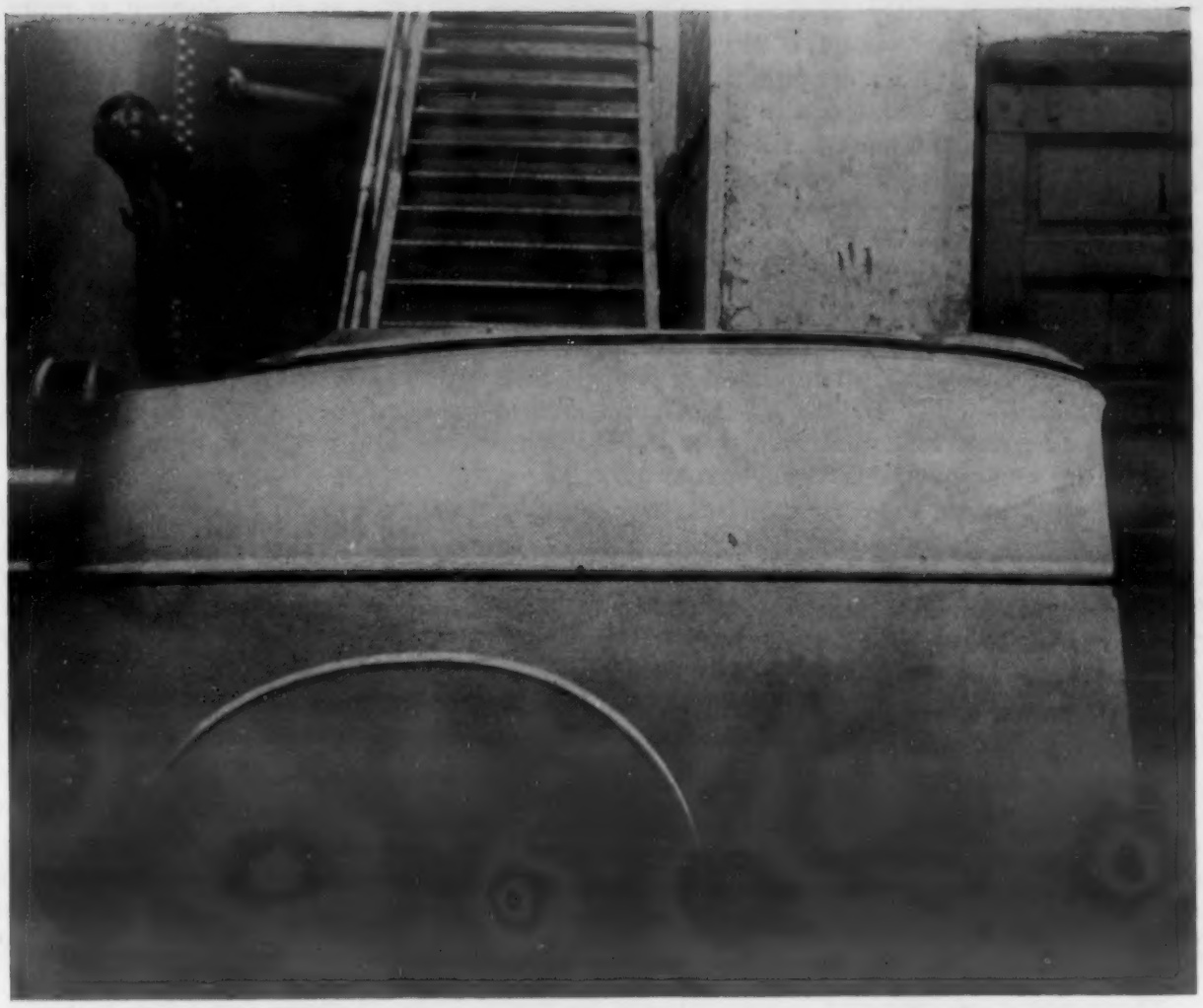
Some steel producers believe that the optimum grain size for deep-drawing is 100 grains per sq. in. This type of sheet will average about B42 Rockwell. A grain much finer than 100 per sq. in. is too hard, while a coarser grain results in an orange-peel or granulated surface that the stamper must polish before he can deliver it to his customer.

It is generally conceded that, in drawing, the best sheet has low Rockwell hardness, B38 to B42, high Olsen cup values, low elastic limit, high tensile strength and high elongation. The elastic ratio, which is defined as the elastic limit divided by the tensile strength, should be low for deep-drawing sheets. This will give a sheet which is not susceptible to the formation of stretcher strain.

The average Rockwell hardness and the corresponding grain size required for various applications are as follows:

Rockwell Hardness	*Average Grain Count*
B54	384
B51	288
B48	192
B45	144
B42	96
B39	72
B36	48

Small grain size steels with an average count of



The drawing of non-symmetrical parts, such as this truck side panel, requires special care in lubrication and choice of steel.

200 to 384 grains per sq. in. are not deep-drawing materials, yet they are needed in forming certain parts. Steels with a grain size of 180 to 192 lend themselves readily to roll formations, where fluting is undesirable and a certain amount of spring back is desired.

Steel with a grain count of approximately 145 lends itself very readily to roll formation without fluting and with minimum spring back. A grain count of 95 is satisfactory for deep and extra deep draws, while steel with a grain count of 48, when deep-drawn, has a definite tendency to produce an open-surface or orange-peel effect.

Elimination of Stretcher Strains

The term stretcher strains or Luder lines is used to describe a condition that is encountered in the stretching or elongation of steel sheets. These lines, which occur in sheets of high elastic ratio, are the result of necking or localized reduction in cross-sectional area.

In commercial cold-rolled steel, fully annealed, yield point elongation will run from 3 to 5% of the total elongation. Sheets of acceptable drawing qualities, untreated for strains, should be within 3 to 7%. However, one can hardly expect to elongate all zones in an irregular deep-drawing to a mean of 3 to 7%.

Three general methods of eliminating or reducing these strains are available. One is to give the sheets a temper or skin pass of 0.5 to 2.0% reduction for the elimination of much of the yield point elongation. A second method is to give a light skin pass followed by a light stretcher levelling. The third method is to roller level. This method often has to be used even where the sheets already have had a light skin pass at the mill.

Although it produces no apparent changes in structure, it does cause a definite change in the stress-strain diagram. Roller leveling of sheets is usually only effective within 24-hr. periods previous to drawing. Most large users of sheets have their own roller levelers for this work. In some sheets the tendency to produce stretcher strains is so marked that it is necessary to roll the sheets several times and also cross or diagonally roll them. If strains still appear after all these passes, they probably cannot be removed, at least not in the stamping plant. The reason may perhaps have been too light a skin pass at the steel mill.

Die Materials

The ideal die material should be easy to work and readily hardened when necessary. It should be resistant to wear, deformation, abrasion, and seizing during production runs. It should also possess some degree of natural "slipperiness" and must, of course, not be too expensive. Although none of today's ma-

terials completely satisfy all these requirements, it is generally possible, by compromising, to find the material most suitable for any specific job.

Beginning with wood, which is used in art press work, the price of die materials increases with regular gray cast iron through alloy irons to carbon steels, going still higher for alloy steels and reaching the final high with the various complex proprietory alloys such as those used for hard surfacing.

On small dies, where the cost of the material constitutes only a small part of the total cost, the use of the more expensive alloy steels may often prove the most economical. The largest expense in a tool program is, of course, the machining to shape and the final fitting and polishing.

Use of expensive material throughout large, complicated dies is usually not justified. A low alloy cast iron with hardened steel inserts at the points of maximum wear will do the job, with a many-fold increase in die life. Additional life, and other advantages, may be gained either by using a hard-surfacing alloy or by surface hardening the areas around the blank holder where the greatest flow of metal occurs.

Machinability of large plain cast-iron dies is mainly determined by the graphitic grain size. There should be no hard spots or local chilling. In alloy cast irons the ease of machining decreases as the alloy content goes up because the alloys increase the toughness of the pearlitic matrix.

Three stages are involved in preparing a die for a production run:

1. Rough shaping. The final cost will depend upon the equipment used, but many hours of machining time may be saved if the Keller die sinker is used. In this machine, electrical control of a mechanical finger, which under light pressure passes over a pattern of the desired shape, actuates the cutter in three dimensions and thus reproduces the pattern in the rough casting or forging.

2. Final finishing. After rough machining, the dies are filed and ground by hand.

3. Polishing. Cast iron dies polish easily and maintain their polish throughout their life. On harder die surfaces the polishing is more difficult and requires longer time. Polishing is a very important factor in the final performance of the die, and it is one factor which is most generally neglected. Manufacturers who have produced aluminum stampings soon learned that the more highly a die is polished, the less hand work has to be done on the finished piece. This also holds true for steel stampings, but it is often overlooked. The result is that throughout a production run it is necessary frequently to stone the die to remove scratches. The importance of high polish cannot be stressed too strongly, as it means better die performance, less stamping breakage and less subsequent work on the stampings.

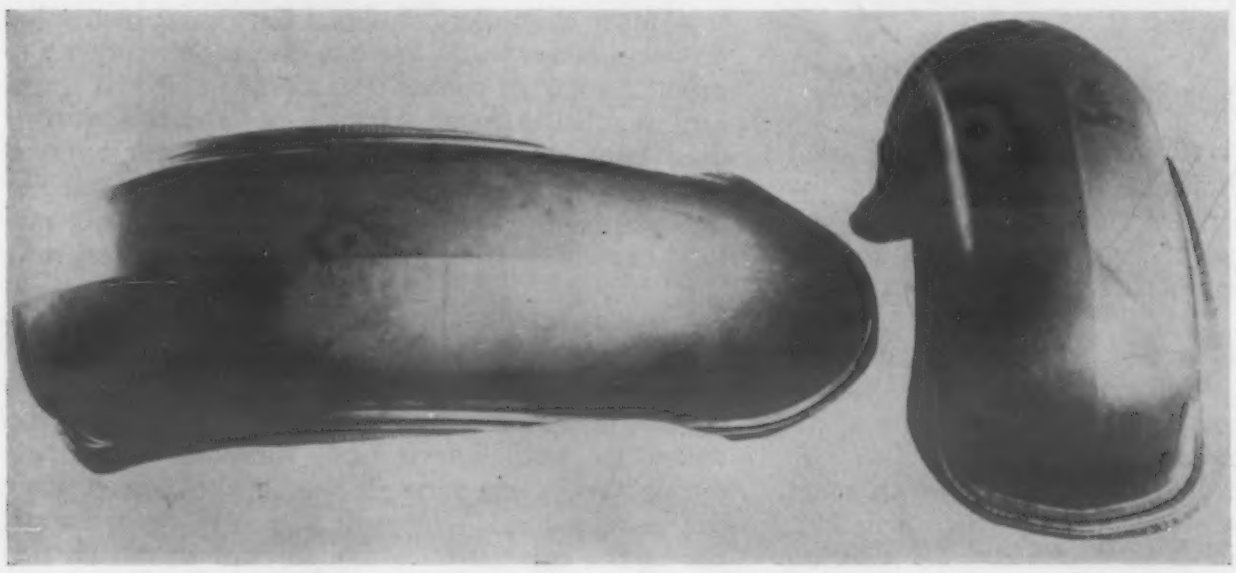
Die Abrasion and Lubrication

There are two main causes for the abrasion of the dies: first, foreign particles which are carried to the dies and the work by air and the lubricants, and second, oxide coating on the sheets. Such coatings cause untold damage to the dies and will eventually roughen even the hardest steel. When it is necessary to use unpickled sheets, the cheapest die material that can be used is sometimes the most economical.

A light oxide coating, similar to the temper color on cold-finished sheets that have been exposed to annealing leakage, will often act as a lubricant, and care must be exercised in handling such sheets. In making fender blanks from a batch of sheets with a film of oxide along one edge, it was found most difficult to control the flow of metal, as the oxidized edge flowed across the blank holder with greater ease than the edge which was free from oxide.

Seizing or galling is the result of a natural affinity of the molecules in the die steel for the molecules in the metal being worked. The greater the difference in hardness between the die material and the sheet steel, the less seizing will take place.

Nonferrous metals would be excellent materials for eliminating seizing, but they lack the core strength required in dies. Hard chromium surfacing meets the nonferrous requirement and also possesses a natural slipperiness that makes it an ideal die material.



Truck fenders, although easy to form, present difficulties in avoiding stretcher strains.

Chromate treated parts are moved slowly through a 150 F oven after surplus water has been removed by air blast. (Courtesy: New Jersey Zinc Co.)

Chromate Finishes to Protect Zinc Surfaces

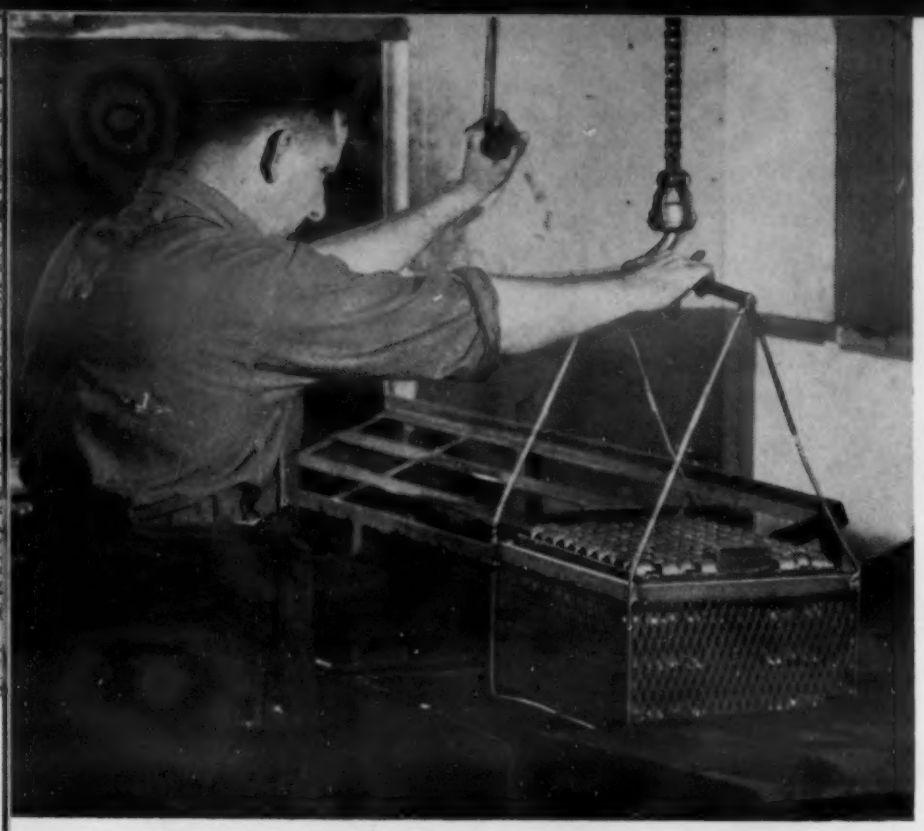
by GEORGE BLACK

FOR MORE THAN A CENTURY, zinc has been used successfully as a corrosion resistant material. The slow and uniform weathering it exhibits under the majority of exposure conditions has been responsible for the continued expansion in the use of zinc alloy die castings, rolled zinc and zinc electroplate.

Observation has shown, however, that when zinc is exposed to stagnant moisture with limited access to oxygen, or to slow drying films of condensed moisture, a non-uniform type of corrosion occurs which results in the formation of bulky white corrosion products. In addition to causing an unsatisfactory appearance, this irregular corrosion formation may prevent proper functioning of close tolerance units. With this in mind, the joint Army-Navy specification for requirements of zinc plating specifies that the plating be treated in such a manner that the formation of white corrosion products will be appreciably retarded during the standard salt spray test.

Long before government specifications called attention to this need, the wide awake research units of interested corporations were busily working out simple dip treatments to enhance the beauty and increase the corrosion resistance of zinc surfaces. It is the purpose here to present and discuss some of

Although zinc is highly resistant to corrosion, its use in certain atmospheres results in irregular corrosion which is slowed by simple treatments.



These small parts are ready to be dipped in the Cronak tank for treatment. (Courtesy: New Jersey Zinc Co.)

Table 1—Characteristics of the Cronak Process

Application:	1. Clean thoroughly 2. Double rinse in cold water 3. Immerse in Cronak solution 4. Double rinse in cold water 5. Blow dry with compressed air
Appearance:	Iridescent to golden brown
Operating Conditions:	1. Room temperature 2. pH 0.9 to 1.5 3. Agitation limited to motion required by equipment 4. 5 to 30 sec. 5. Maximum draining time prior to final rinses—30 sec. 6. Avoid hot water rinses 7. Avoid handling until thoroughly dry
Thickness:	Approximately 0.00002 in.
Container:	Glazed earthenware, stainless steel, ingot iron or S.A.E. 1010 steel plate.

the leading chromate passivating treatments which have grown to such popularity during the past few years. No attempt will be made to cover processes involving the use of electric current, and since comparative corrosion data is not available for all the processes to be discussed, it is emphasized that no choice should be made by product engineers until they are certain that the process chosen meets at least the minimum demands of their product.

The impossibility of describing all available processes, as well as the impracticability of such a presentation, has led to the choice of three major lines of zinc after-treatments. First to be discussed will be the senior treatment, Cronak, which was patented over a decade ago by the New Jersey Zinc Co. We shall then present the Iridite line, marketed by Rheem Research Products with such tremendous success during the war. And, finally, the newest series of surface coatings, presented by United Chromium, Inc., known as Unichrome Dip.

The Cronak Process

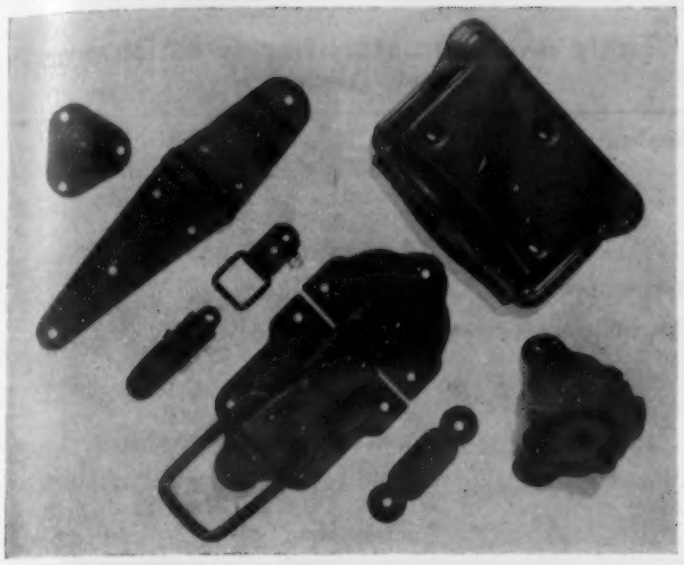
Fundamentally, the Cronak process consists of applying a film of basic chromium chromate by immersion in an acidified solution of sodium dichromate. Since the film is formed by chemical interaction of the solution and the surface, thorough cleaning prior to immersion is a necessity. The only zinc surfaces which can be treated without some type of cleaning operation are freshly produced electrodeposited coatings.

After thorough cleaning and rinsing, the parts being treated are immersed in the room temperature Cronak solution for a few seconds. They are then rinsed in cool water and blown dry. The film formed by this simple immersion method is thin and adherent. It will vary in color, depending on the original surface and the duration of the immersion. Unalloyed rolled zinc, zinc alloy die castings and zinc coatings containing no copper will acquire a golden brown colored appearance: when copper is present in the alloys, the film assumes a dark, greenish tone. The time of immersion has a definite effect on the appearance, thickness and adherence of the film.

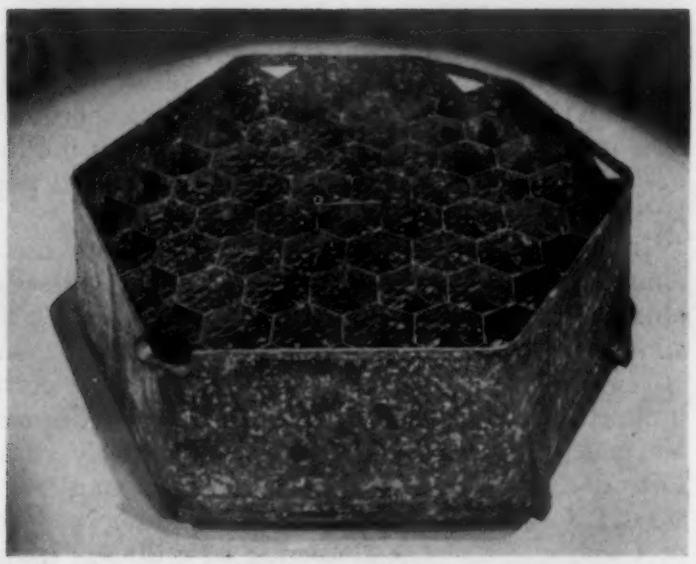
Generally speaking, the color darkens and the thickness increases with increase in time. The film produced by 5-sec. immersion is usually so thin that it appears highly iridescent, and the golden brown iridescence which characterizes the Cronak film is formed within 30 sec. Longer treating time should be avoided.

In order to find out the actual protective value of their Cronak process, the New Jersey Zinc Co. conducted a series of corrosion and outdoor exposure tests. Data compiled indicates quite clearly that Cronak treated zinc retards the formation of white corrosion products extensively, when the parts being tested are subjected to stagnant or condensed moisture. Exposure to normal outdoor atmosphere, where parts wet with rain, mist or dew dry relatively rapidly, involves a different mechanism entirely. Under outdoor exposure conditions, the Cronak film gradually loses the golden color, leaving a pale, greenish-blue film similar in appearance to the normal outdoor corrosion film which forms on bare zinc. These test results show conclusively that the Cronak film on zinc-coated steel, when exposed in industrial atmospheres, does not extend the time to rusting by more than a few percent. In other words, the Cronak film reduces sharply the extent of corrosion by contact with condensed or stagnant moisture, but it cannot be considered a substitute for an adequate thickness of zinc coatings for outdoor exposure.

Control of the Cronak solution by means of a pH meter equipped with a glass electrode is a relatively simple matter. The pH of the bath is maintained between 0.9 and 1.5 by routine checking and additions of sulfuric acid as required. Where pH equipment is not available, a simple expedient has been used in commercial practice. A known quantity of the Cronak bath is removed and small acid addi-



The Iridite finish on these zinc-plated pieces of trunk hardware is used as a base for a final paint coating. (Courtesy: Rheem Research Products.)



This illustration shows the Iridite treated galvanized cooler of a vending machine after a year's service.

tions are made to it until a sample dipped under appropriate conditions becomes coated with a satisfactory film. The same percentage additions are then made to the bath.

The use of a specially prepared chromic acid type of solution instead of the usual dichromate process permits the application of Cronak films to hot dip zinc coatings. Neither solution, however, will form films satisfactorily on zinc-iron alloys; and hence, the Cronak process is not applicable for tight-wiped galvanized or Sherardized products on which there is no pure zinc layer. Application details for the chromic acid process are similar to those described for the regular Cronak treatment. Table 1 lists some of the important characteristics for successful application.

Films of unsatisfactory appearance or quality can be removed prior to retreatment, by immersion for several minutes in a boiling solution of 200 grams of sulfate-free chromic acid per liter of water. Freshly produced films are more readily removed by this procedure than those which have been permitted to harden. If any difficulty is encountered in retreating stripped work, passage through the alkaline cleaning cycle should eliminate the trouble.

The Iridite Process

The Iridite line of protective finishes for zinc surfaces was developed during World War II and was widely used as a protective and camouflage finish on many types of equipment, such as cot hardware, fuzes, radio, radar and aircraft parts, ammunition containers, etc. Its popularity has continued in peacetime production, and the original olive drab finish has had its face lifted to meet the appearance demands of washing machines, office equipment, hardware, automotive equipment and the like.

Iridite Olive Drab, the first of the many Iridite coatings, is applied by simple immersion at room temperature for approximately 60 sec. It forms an attractive olive drab surface that is uniform in color, does not alter the texture or dimensions of the surface, and greatly retards the formation of white corrosion products. Increasing the time of immersion or raising the temperature of the final rinse appreciably dulls the surface.

In order to process with maximum efficiency it is recommended that the pH be maintained between 2.8 and 3.2. Mild agitation of the work while in the solution insures uniform coverage. Ordinarily Iridite Olive Drab can be applied immediately after plating, without the necessity for bright treatments. If, however, the parts have become oxidized due to delay in processing, immersion in a dilute nitric acid solution is required. Recommended uses for Iridite #1 (Olive Drab) are zinc plated parts, zinc alloy die castings of low copper content, and sheet zinc. In all cases the finish can be used as a paint base or as a final serviceable and decorative coating.

Iridite #2, referred to as Galvon, was developed as a protection for galvanized surfaces and as a finish for all zinc alloy die castings. Its use as a finish for die castings has been suspended in favor of Iridite #3 (Bronze), but it ranks high among the coatings in use for galvanized surfaces. Operated within a tem-

Table 2—Characteristics of Iridite Olive Drab

Application:	1. Clean thoroughly 2. Water rinse 3. Immerse in Iridite 4. Cold water rinse 5. Hot water rinse 6. Dry
Appearance:	Uniform olive drab
Operating Conditions:	1. Room temperature 2. 2.8 to 3.2 pH 3. Approximately 30 sec. 4. Mild agitation
Container:	Acid proof brick tanks, stoneware crocks, koroseal or tygon-lined tanks.

perature range between 75 and 90 and at a slightly higher pH than the Olive Drab finish, successful coatings are applied within 30 sec. Experimental tests have shown that Iridite Galvon reduces the force of galvanic corrosion when in contact with all popularly used metals except magnesium.

Iridite #3 (Bronze) is recommended for use on zinc surfaces when the olive drab color is objectionable, and as the best of the Iridite finishes for zinc alloy die castings. The most satisfactory bronze color is obtained by a 40-sec. immersion at 80 F. As the immersion time increases, the iridescence decreases, and the bronze color becomes progressively darker. Directions for application to zinc electroplate are similar to the other Iridite coatings, but a special precleaning treatment consisting of a 20-sec. immersion in a 4-oz. per gal. solution of tri-sodium phosphate at 170 F, a 15-sec. immersion in a 6-oz. per gal. solution of caustic soda at 200 F, a cold water rinse, and a 15-sec. immersion in a 0.3% by volume sulfuric acid is required.

There are other Iridite treatments worthy of investigation by product engineers and finishing personnel, but the three mentioned above are those which give maximum corrosion resistance. They may be produced with a minimum of control requirements and can be relied upon for consistency and uniformity. The abrasion resistance of the coating can be increased by baking at approximately 250 to 300 F for 10 min. Although this baking treatment reduces the salt spray resistance of the film, it substantially increases its resistance to mild acids and alkalies.

Laboratory tests indicate that the Iridite finishes are excellent paint bases. The vehicle component of paint formulations is extremely important with respect to adhesion of paint coatings to these chromate films. Paints containing nitrocellulose, phenolic resin and cooked phenolic resin varnish vehicles are unsatisfactory for use over Iridite. Some satisfactory vehicles are vinyl plastic, urea formaldehyde and alkyd resin and cooked ester gum varnish.

Unichrome Dip Process

Among the newest of zinc protection coatings is the Unichrome Dip line, which includes an Olive Drab, a Black and a Clear Dip. These three comparatively simple immersion treatments require no filtering, ventilating, agitation or electrical equipment.

The Olive Drab Dip for zinc surfaces is a simple means of applying an olive drab protective coating which increases both the corrosion resistance and the appearance. Within the specified temperature range, 60 to 90 F, brighter and more resistant coatings can be applied if the lower limit is approached. In general, uniform coatings can be applied within 1 to 5 min. The longer the immersion period, the darker the color and the greater the wear resistance. Although some zinc die cast alloys give a gray color rather than the usual olive drab, the corrosion resistance is not impaired. Maintenance of the solution to replenish drag-out losses requires adjustment at regular intervals to the recommended Baumé value.

Table 3—Characteristics of Unichrome Olive Drab Dip

Application:	1. Clean thoroughly 2. Water rinse 3. Immerse in Unrichrome Dip 4. Cold water rinse 5. Dry
Appearance:	Uniform olive drab
Operating Conditions:	1. Room temperature 2. pH 0.8 to 3.0 3. Density—10 to 30°Bé 4. 1 to 5 min. 5. No agitation required
Container:	Unlined stainless steel tanks, brick-lined (with acid-proof backing) steel tanks, or acid-proof crocks.

The main characteristics of the bath are described in Table 3.

The Unichrome Black Dip for zinc coatings provides a lustrous black surface with a single dip, and is applied in accordance with application instructions for the olive drab film. The upper part of the pH range is used to obtain the darkest color; and, as in the olive drab coating, low temperatures favor bright coatings with maximum corrosion resistance, while longer dip periods darken the color and improve the wear resistance.

The most lustrous black is produced by drying quickly in a centrifuge or by means of a cold air blast. Hot water should not be used for rinsing or to speed drying, as it will tend to dull the finish and to decrease the corrosion resistance.

The Unichrome Clear Dip for zinc surfaces is a simple and economical means of applying a clear, bright corrosion-resistant coating on zinc plate. The ordinary pH meter is not suitable for checking this solution, and for maintenance purposes, special Unichrome Dip papers have to be used. The specific gravity must be maintained between 1.14 and 1.23 with a Baumé reading between 17 and 27 deg. The solution is operated between 60 and 80 F, and proper application is made within 5 to 20 sec.

After double rinsing to insure complete removal of processing solution, parts are given a 30-sec. dip in boiling water. This not only facilitates drying, but serves to remove any discoloration caused by traces of the dip solution clinging to the work.

Cronak, Unichrome Dip and Iridite are but a few of the many treatments designed to increase the corrosion resistance and the appearance of zinc coatings. During the past few years there has been a tremendous increase in the use of other chromate passivating treatments, phosphate coatings and anodic conversion coatings. The choice of the coating must depend upon the end result demanded, the available money and equipment, and the time and space allotted to processing. No choice should ever be made without a comparative study of operating conditions and results. Although the use of zinc has been on the upgrade for a long time, the recent research developments lead one to believe that the peak is still a long way off.

5

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MATERIALS & METHODS MANUAL

25

This is another in a series of Manuals on engineering materials and processing methods, published at periodic intervals as special sections in Materials & Methods. Each of them is intended to be a compressed handbook on its particular subject and to be packed with useful reference data on the characteristics of certain materials or metal forms or with essential principles, best procedures and operating data for performing specific metalworking processes.

A Plastics Primer for Engineers

by Kenneth Rose,

Engineering Editor, MATERIALS & METHODS

To the man who does not work with plastics every day there is likely to be considerable confusion in the welter of chemical and trade names with which he must contend. Therefore, in preparing this manual, the author has sought to keep his explanations, of the various groups and types of plastics, as simple as possible. All commercially available types of plastics are described, classified, discussed and their chief uses suggested. Valuable, too, is the table which lists the trade names under which the principal plastics are available.

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Materials & Methods, April 1947

(Published since 1929 as Metals and Alloys)

These Textolite parts for ultra-high frequency use have a low power factor and relatively high resistance to heat distortion. (Courtesy: General Electric Co.)

Introduction

Although plastics are not new, the widespread use of plastics as industrial materials is of comparatively recent date. The great number of new types of plastics produced in recent years has so widened the field of applications that today engineers in all branches of industry are finding it necessary to know something about these interesting synthetics, their properties, and the methods of working them.

The number of types, the chemical names that indicate their composition, and the trade names that designate various marketed products or materials, properly included with the plastics, combine to create a situation confusing to the engineer in another branch of industry who wishes to acquire a fundamental knowledge of these new materials. It is to help these engineers, designers, executives, and others having no knowledge of plastics, but wishing to obtain a groundwork of general information about them, that this manual is written.

Use of trade names to identify the plastics produced by a manufacturer created no great difficulty when there were only a few kinds of plastics available, and fewer suppliers. Now there are more than 30 chemically distinct plastics families, and numerous formulations of many of these basic types. Certain of these types may be reinforced with a fibrous material, or loaded with an inert powdered material called a "filler." When the fibrous reinforcing is used, producing the "laminates," additional variation is possible in the physical properties of the end products by varying the type or characteristics of the laminating material. A single chemical type may be made in several different physical forms, such as nylon filament or molding powder, or cellulose acetate sheet or cellular material. In addition, there are now being produced several "blended" plastics, in which chemically different plastics materials are combined in intimate mixes of various proportions. Finally, it is the practice of many molders and other fabricators of plastics to confer their own trade names upon the plastics materials they have worked. The result of the entire situation is that hundreds of different plastics materials are offered to industry under trade names that, usually, have no relationship to their chemical composition or physical properties.

The Society of the Plastics Industry made an attempt to bypass this confusing situation several years ago by preparing a classification for all basic types of plastics, modelled upon the S.A.E. classification for steels, and using coded physical properties as its type numbers. It has so far failed to achieve general acceptance, due partly to the fact that physical properties are not always the determining factors in the selection of a plastic for a given application.

In the choice of a material, then, the engineer is still dependent upon his knowledge of the general physical and chemical properties of the basic types, the methods by which they can be fabricated, and the variations possible within the type of reinforcing or other means. For convenience in selecting the basic type decided upon from among the materials commercially available, he must be able to associate the various trade names with chemical types. Finally, his tentative choice should be checked with the technical service department of the producer, to make sure of the suitability of the material in question for the intended use.

When concerned only with basic types of plastics materials, the problem of associating trade names with chemical compositions is not formidable. A listing, given in another part of this manual, of standard types, trade names, and manufacturers should be of assistance.

General Nature of Plastics

In thinking of plastics, the first question likely to occur to the engineer is, "What is a plastic?" Because of the diversity of materials and manufacturing processes involved, it is not easy to arrive at a definition that will include the entire group. Perhaps the simplest is "an organic solid, polymerized to high molecular weight, that is or was capable of being formed by

low, usually with the aid of heat or pressure, or both." Awkward as this definition is, it is somewhat simpler than the official definition given by the Society of the Plastics Industry, which states that a plastic is "any one of a large and varied group of materials which consists of, or contains as an essential ingredient, an organic substance of large molecular weight and which while solid in the finished state, at some stage in its manufacture has been or can be formed into various shapes by flow, usually through application singly or together of heat and pressure."

An essential thought in this definition is the one giving the name to the entire group—that of formability by flow. It is this "plasticity" of the materials—this ability to be formed—that characterizes the group from the engineer's viewpoint, as well as from the layman's. The engineer is acquainted with flow in metals, both hot and cold, and makes use of it in forging and pressing, drawing, extruding, and similar forming operations taking place below the melting point of the metal. The phenomenon is much less common among the nonmetals, if casting of the truly molten material and simple bending of the cold material be excluded. Certain of the plastics can be cast, but in this case casting is simply pouring of the cold liquid resin into a mold, and letting it solidify by chemical change rather than by freezing. When most other nonmetallics are molded, a foreign substance (a binder) is used to join very fine particles of the nonmetallic, or the material is fused and poured before freezing.

Moldability is perhaps the most valuable forming property of the plastics. It permits them to be made into any shape for which a die can be made, and with all the economies of this high production method. While several important groups of plastics utilize molding to a limited extent only, as will be shown, and increasingly large tonnage of films and coatings are being made, molding remains the production method most generally associated with the plastics.

Nature has produced a few substances that might be called plastics, in that they possess this property of formability by flow. Bitumen is one, and, occurring as such in the Middle East where civilization had its beginnings, was used in ornamenting buildings in some of the ancient cities of Sumeria. Another natural plastic, lac, has long been used in the Orient, although seldom in a way that shows recognition of its true plastic properties. It is a resin secreted by a species of scale insect as it feeds upon the small branches and twigs of certain trees, and has been an important article of commerce in northern India and China for many years. It formed the basis of lacquer, and, more in keeping with true plastics properties, of sealing wax. It is still important in modern technology as an alcoholic solution of the resin, familiar as shellac.

The Older Plastics

The first of the synthetic materials that we now know as plastics was developed in 1868 by John Wesley Hyatt, of Albany, N. Y. Seeking a substitute for ivory, in competing for a $10,000 prize offered for a material suitable for use in making billiard balls, he produced celluloid. It was made from cellulose nitrate treated with camphor, and heated and compressed. Celluloid could be molded, and soon became a preferred material for toiletware, collars, and similar articles. Its ready flammability was a drawback.

The same century saw the beginnings of several other plastics families. About 1890 the casein of skimmed milk was converted into a hornlike solid by treatment with formaldehyde. It was nearly thirty years later that these plastics were imported from Europe to the United States. The development of the phonograph brought the need for a plastic for records, and a composite based upon the natural resin, lac, was developed about 1895.

The father of modern plastics was a Belgian chemist, Dr. Leo H. Baekeland, who came to the United States while still a young man after graduating from the University of Ghent. He made a fortune by his work in photochemistry, and then in 1909 started a long series of researches into certain reactions between phenol and formaldehyde that had been reported from Germany. He obtained an amorphous mass that could not be melted after having been formed, that acted as a nonconductor of electricity, and was highly resistant to the action of many chemicals. Dr. Baekeland was a very practical man as well as a brilliant chemist, and he foresaw many fields of application for the material with the unusual properties he had developed in his laboratory. He called it Bakelite, and wrote it with the symbol for infinity to indicate its apparently limitless possibilities. Bakelite became the first of that important group of synthetic resins now called the phenolics, and remains today one of the most useful of the industrial plastics.

The natural plastic, bitumen, was revived about 1909 as the basis for cold molded composite plastics containing asbestos and other ingredients. These are molded under pressure, but without application of heat.

Modern Developments

During the past 20 years progress has far surpassed that of the preceding sixty. The alkyd resins, much used in paints and varnishes, were developed about 1926. Cellulose acetate, slow burning, appeared in 1927 to supplement and gradually to replace the combustible celluloid. The first of the styrenes and vinyls were announced in 1930, and a new composition resembling the original Bakelite was produced, the new material being a urea-formaldehyde resin. The following year saw the introduction of the acrylics. Cellulose acetate butyrate was announced in 1932.

The glasslike methyl methacrylates were first produced in this country in sheet form in 1936, and the next several years saw the development of new esters and copolymers among the cellulosics, vinyls, and styrenes. During the war years plastics based upon the allyl esters, ethylene, new styrene copolymers, tetrafluoroethylene, and finally upon an entirely new linkage containing silicon in an organic chain, giving the silicones, were announced.

This list has omitted the synthetic rubbers, the use of natural rubber, and the development of vulcanizates of both natural and synthetic types. The synthetic rubbers occupy an anomalous position, in that they fall within the meaning of the definition of plastics, but their development and application have been closely associated with the rubber industry. Rubber is itself a natural plastic, but so great an industry has grown up around it that it is usually considered separately for practical purposes.

Another group of plastics must be included with the wartime developments in the industry, however. These are the plastic "blends," in which plastics of several different types are combined with synthetic rubbers, and new

materials of intermediate properties result. These have included blends of oil-resistant synthetic rubbers with phenols and with vinyls, and doubtless other combinations are possible and will be made commercially.

The Timeliness of Plastics

The quick acceptance of plastics by both industry and the public as valuable materials has been due to a unique combination of properties. In addition to being unique among the materials, many of these properties were offered by plastics at precisely the time when they were in demand. Thus, the development of plastics closely parallels, chronologically, the development of the airplane; it is not mere chance that lightweight plastics have begun to go into the aircraft industry over the past 15 years especially, when commercial aviation was demanding weight savings in trim and accessories. Likewise, plastics with unlimited color possibilities were produced at the time when the buying public had begun to demand color in the home and its furnishings, in apparel, in automobiles, trains, everywhere.

Bakelite was first produced in 1909, and the period since then has witnessed a tremendous expansion of the use of electricity in the home and in industry. One of the first large-scale users of Bakelite was the electrical industry, and its use as an electrical insulator still accounts for a large part of the annual production.

When industry was developing present-day high-speed mass production techniques, the plastics industry was adopting injection molding and extruding methods that offer high-speed production of parts needing only slight touching-up to finish. Machining, grinding, polishing, and similar operations required to produce a good surface on most metal parts are often unnecessary with plastics. In speed of production and elimination of additional finishing procedures only die casting can compare with the molding methods for plastics, and die casting can make use of only a few alloys.

The most recent example of the timeliness of plastics has been in the field of ultrahigh-frequency insulation. With the usable frequencies in dielectric heating going higher, with radar as both a military and civil development demanding frequencies in terms of megacycles, and with television gradually increasing in use, insulators for these currents had to be found. Several new plastics with the required properties were produced exactly when needed most, and are today the best insulators available for these megacycle frequencies.

General Properties of Plastics

The combination of valuable properties offered only by the plastics has already been mentioned. These properties in general are:

(1) *Light weight.* Most kinds of plastics will weigh less than magnesium, lightest of the structural metals. A good general weight figure, excluding such specialties as the lightweight core materials and foamed plastics, would be about 1.35 to 1.4 specific gravity. This puts the plastics definitely into the category of lightweight materials.

(2) *Good electrical insulation.* The importance of plastics to the electrical industry, and the importance of the insulator market to the plastics industry, have already been suggested. Plastics have many competitors in the field of ordinary electrical insulation, where porcelain, rubber, and various other moldable materials are available and suitable, but competition fades away as the ultrahigh-frequencies are approached. The probable expansion of the use of television and radar will put several of the new plastics, particularly several of the styrenes and polyethylenes, in the same position as favored materials that Bakelite had won in the lower-frequency applications.

(3) *Good heat insulation.* The low heat conduction of plastics is used to advantage in such applications as handles for electric irons, for pots and pans, for soldering irons, and for miscellaneous small tools.

(4) *Resistance to atmospheric corrosion.* While plastics are not corroded upon exposure to air, their durability in outdoor use is variable. Some of them resist weather excellently, but others absorb moisture to such a degree that they soon deteriorate. The thermosetting resins, and particularly the phenolics, have low moisture absorption rates generally.

(5) *Mechanical properties.* These vary widely. By way of illustration, the ordinary general purpose phenolic may have a tensile strength of about 6,000 to 8,000 psi. When made with a wovan canvas laminating material, the strength may rise to about 10,000 to 12,000 psi. Yet laminates have been prepared with glass cloth as the filler that have shown tensile strengths of 80,000 psi. and higher.

Other strength properties likewise show a wide variation. The thermosetting materials tend to be brittle when made without a filler, but high impact values can be obtained with the laminates. Use of plasticizers also increases impact strength in the thermoplastic materials.

(6) *Fabricating possibilities.* Plastics are machinable, but certain of the thermosetting laminates, especially those in which glass fibers serve as the laminating material, are abrasive and require the use of carbide tools. Machinability is not as important in connection with the plastics as with the metals, as plastics are to a great extent molded to finished shape.

Molding is the most important fabricating method used with the plastics. High-speed molding presses are available, but rates of operation are limited by the necessity of holding the pressure until the molded material has cooled sufficiently to hold its shape when removed from the mold. Good production is obtained, however, especially in the case of the small molded objects that form a large share of the total of plastics products.

Plastics cannot be welded in the way that metals are welded, but several cementing processes are used when necessary. Mechanical fastening can, of course, be used for joining plastics in the same way that metals are joined. In the case of the thermoplastic materials, several special techniques can be used that closely resemble fusion welding of metal. Heat sealing by dielectric heating is much used for joining light films. Friction welding has been successfully used in the joining of small parts.

(7) *Pleasing appearance.* Of great importance in consumer goods, this quality includes such considerations as surface finish and color. Most plastics can be given a high luster by a simple treatment with a chemical solvent, but the molding operation will usually produce parts with a finish that does not require polishing. Plastics can be metallized if a metallic luster is desired.

A wide range of colors can be obtained by adding suitable dyes to the plastic at some stage in its manufacture.

These colors are through-and-through as contrasted with painting or other surface coloring of metals. Dark colors only are feasible with such plastics as the phenolics, while others are unlimited in their color possibilities.

This matter of color is closely associated with plastics in the public mind. It is one of the factors contributing to make plastics a "glamor" material, whatever that may mean, but it also gives them a sales advantage that is more easily evaluated.

Finally, plastics give industry several of its few materials of truly glass-like transparency. Some of these are now being ground for optical lenses, after having served for gun turrets in aircraft during the war. They are familiar in such articles as toiletware and small ornamental pieces.

Grouping the Plastics Families

It must be remembered that the materials lumped together under the name plastics are exceedingly diverse in their properties. Perhaps as good an illustration as any one article can provide is found in the plastics binoculars developed during the war. Here one plastic was used for the lenses, as clear as glass; another formed the rigid and opaque frame of the instrument; and a third formed the flexible, leatherlike case.

This property of moldability becomes of importance again as a means of classifying the plastics families. One difference at once appears—some of the plastics can be warmed to a plastic state and molded, then warmed again and again molded; others cannot be reheated to plasticity after once having been formed. The difference is fundamental. In the case of the first group, termed the thermoplastics, softening under heat occurs as it does in metals, while with the second group, called thermosetting, a chemical change occurs, usually at the time of the application of heat and pressure during forming. As a result of this chemical change the material does not soften upon subsequent heating, but chars or is destroyed if the heating is carried to excess.

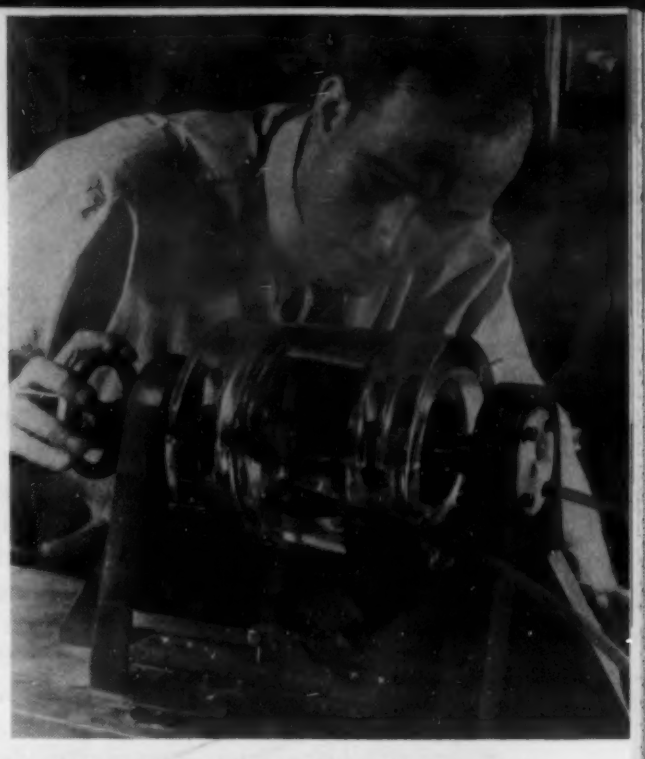
The first of the modern plastics, celluloid, was of the thermoplastic type. It could be heated and formed to a wide variety of shapes, making it a versatile material for the production of many small items. It could be colored through and through, in contrast to painting or other surface coloring. The second material of importance, phenol-formaldehyde resin, was thermosetting.

It should be pointed out that the thermoplastic materials do not actually melt, in the same sense that metals melt. Rather, they soften gradually under heat, as glass softens, and can be molded under pressure.

The property of resoftening under heat is not only a convenient means of dividing the plastics materials into groups, but an extremely important industrial attribute also. Broadly speaking, it divides the plastics into those that are primarily industrial materials of construction, and those that are easily molded or otherwise formed into consumer or industrial items for specialty use at room temperature. This is an oversimplification, but it points out the general trend of each group.

The thermosetting plastics are in most cases stronger, more heat resistant, harder, and lower in cost. In addition, they can be used to impregnate fibrous material, and so prepare laminated or other filled plastics having higher strength and impact resistance than the plastic alone. The combination of properties dictates their use for load-carrying members, where resistance to distortion at elevated temperatures is a determining factor, where pricing must be competitive with lower-cost materials, and where creep resistance is important.

When the cost of forming must be held to lowest limits, and when the shape of the part is not too intricate, the higher speed of injection molding is an advantage. It can be used only with thermoplastics. While most of the thermoplastics possess lower heat resistance than the thermosetting types, the gap between them is being closed. Earlier thermoplastics softened at temperatures of about 140 to 180 F, but there are now available resins that can be used up to about 250 F, and a few of the newest are usable at temperatures above 300 F. This temperature, 300 F, is usually given as the top working temperature for the thermosetting resins, so the thermosetting types would seem to be gradually losing the advantage they once held for applications requiring resistance to deterioration at elevated temperatures.



Transparent Lucite acrylic resin is used here to make working parts of a journal bearing so effects of design changes can be studied. (Courtesy: du Pont Co.)

The thermoplastics generally have better color possibilities than the thermosets. This helps to give them an advantage when used in consumer goods. Another field until recently held exclusively by the thermosetting plastics has been invaded by the thermoplastics —the laminates. Thermoplastic laminates are not yet important commercially, but they have several advantages over the thermosetting laminates that promise to make them serious competitors in the future.

It is helpful to understand the process of forming plastics before taking up the study of the plastics families. The materials from which the plastics are made are produced by the large chemical companies, and supplied to the plastics industry as: (1) molding powder, or flake, or granular material; (2) sheets, rods, and tubes; (3) liquid resins and adhesives. The first type of material will go to the molders, who will form it to finished shape by pressure, and usually heat, between dies. The second kind will go to the fabricators, who will machine it to the desired form just as metals would be machined from bar stock or tubes. The liquid material will go to the laminators, who will use it to impregnate or coat canvas, paper, glass cloth, or other fibrous sheet stock, this stock later to be molded or otherwise finished.

The primary chemical material, when the plastic consists of one chemical compound, is called a *monomer*. The finishing process then consists of causing this simple compound to combine into larger chemical units, with the aid of, usually, a catalyst, heat, and

pressure. The process is called *polymerization,* and consists of joining the simple molecules into groups of molecules, without effecting any other chemical change. When several different compounds are polymerized together, a *copolymer* results. In the case of those compounds requiring a chemical change to form the plastic, as the phenol-formaldehyde resins, the materials manufacturer effects this chemical change, but does not complete the polymerization. The material can then be melted and formed under pressure, polymerization being completed during this heat-and-pressure stage, called *curing*. A certain amount of time is required for the cure also.

In the case of certain of the plastics materials, a substantial part of the production goes into processes that form it into continuous films, or into extrusions, or as a coating on fabric or paper.

The formulation for a plastic will include the basic chemical compound, and some or all of the following:

(a) A plasticizer, intended to give the material greater flexibility, or to reduce its brittleness. The plasticizer may be solid or liquid.

(b) Filler. This is an inert material that adds to the bulk of finished plastic obtained, usually at a sacrifice of strength and other properties. Fibrous material will improve some of the physicals, however.

(c) Pigments or dyes. These give the desired color to the plastic.

(d) Solvents, etc., can be used to obtain some special effect.

(e) For the laminates, a woven or matted fibrous material, impregnated with the resin in the manufacturing process.

From this list of components, it is apparent that the properties of a finished plastic may vary widely, and any values given are only general, unless the formulation is stated, along with such manufacturing conditions as temperature of molding, time of cure, and pressure of molding, all of which affect the properties.

The various composition types are helpful as a method of grouping the plastics because properties may be generally stated, and limiting conditions may be given for the family of plastics. Despite attempts to put the plastics upon a "properties" basis, chemical composition remains the most convenient means of classification.

The chemical families grouped together as thermosetting resins include the phenol-formaldehydes, the phenol-furfurals, the urea-formaldehydes, the melamine-formaldehydes, the aniline-formaldehydes, and the allyl esters. The thermoplastic resins include cellulose acetate, cellulose acetate butyrate, cellulose nitrate, cellulose propionate, ethyl cellulose, polyvinyl chloride, polyvinyl alcohol, vinyl chloride-acetate, vinylidene chloride, polyvinyl butyral, vinyl acetate, the acrylics, polystyrene, polyethylene, polytetrafluoroethylene, the polyamides, and caseins.

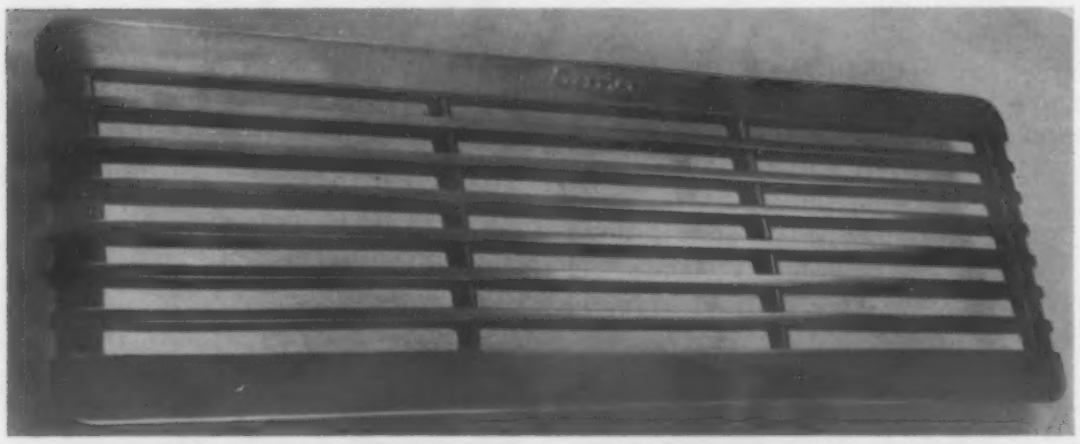
The Thermosetting Resins

Phenolics

The most widely known and one of the most versatile of all the plastics groups is that called the phenolics. It is generally considered to include the phenol-formaldehydes and the phenol-furfurals. While a study of the manufacture of plastics materials is not intended, it must be mentioned that a certain variation in composition can be made, and that such variations affect the properties of the finished plastic. Phenol-formaldehydes, for example, may be made with phenol (carbolic acid), or the phenolic constituent may be certain of the cresols, xylenols, or naphthols, or mixtures of these. The aldehyde constituent is usually formaldehyde, used as an aqueous solution. Furfural forms the aldehyde portion of the phenol-furfural plastics. Acetaldehyde is sometimes used.

Because the phenolics are not polymerization products of a single definite basic composition, but may be polymerized from any or several of various related compounds, the formulations are offered under trade names or formula numbers by the several manufacturers. It should be pointed out that this difference among formulations is a difference in basic chemical composition, not just a difference in compounding the finished plastic; that is, it represents a difference in original constituents, rather than a difference in the amounts of material other than plastic added, such as plasticizer, pigment, filler, and so on. The type of catalyst used has considerable influence upon properties of the finished plastic also.

Based upon the reactions occurring during their production, the phenolics are divided into two types; these are the one-stage resins and the two-stage resins. One-stage resins are prepared with the phenol and the aldehyde present in the proper reacting quantities to produce a thermosetting resin. The proper type of catalyst must be used, and the reaction requires careful control to prevent the material setting up to an infusible mass during manufacture. The resin as manufactured requires only additional heating to complete polymerization to an infusible, insoluble material. Upon the other



This model air conditioning grille was cast from a phenolic casting resin for test purposes. Finally accepted designs were then molded from a phenolic plastic. (Courtesy: Durez Plastics & Chemicals, Inc.)

hand, the two-stage resin is made with only part of the aldehyde necessary to produce a thermosetting resin, and the material will be fusible and thermoplastic as so manufactured. In a later stage, and usually in connection with subsequent operations, the amount of aldehyde necessary to give the proper ratio of constituents is added, usually as hexamethylene tetramine, and the material then becomes infusible and insoluble. Both one- and two-stage resins are used separately or in combination to get various degrees of workability. Physical properties of the finished material of both types are not significantly different.

The phenolic resins were first patented in 1909, and in the following year patents were issued upon the first cloth impregnated material, the forerunner of the laminates. Actual commercial production was begun about 1912, and went into the electrical insulating field. Today, in spite of the many new plastics available, the phenolics still form a large part of the total production of plastics materials, and are probably the most widely used.

With regard to methods of forming, three distinct types of phenolics are recognized. These are:

(1) The molding phenolics, made with a filler, and polymerized in the molding press.

(2) The casting resins, poured into molds as liquids, and polymerized by catalysis and subsequent baking.

(3) Laminating resins, applied to cloth, paper, or other layer material as a varnish, and polymerized by subsequent heat and pressure.

In normal times the molding powders comprised the largest quantity of phenolics used, but during the war such great quantities of laminated materials were needed that, despite a tremendous increase in amounts of molding powders of this type, the laminated phenolics showed a dollar value almost twice as great. The cast resins lagged during the war, but have begun a considerable growth since the resumption of peacetime production.

For the molding powders phenol, mixtures of meta- and para-cresol, some of the xylenols, and formaldehyde or furfural give the best properties. A resin that will possess smooth gloss in the molded part, hard set, fast cure, good electrical insulating properties, and good resistance to chemicals and moisture is desired.

Fillers may be of organic or inorganic material, fibrous or powdery. They lower the cost of the finished plastic, and increase its strength. Shrinkage is reduced also.

Organic Fillers

Woodflour—Ordinarily the cheapest and most used, it is made by grinding wood to about 100-mesh size. Moisture content must be below 8% for best molding and electrical properties. Soft woods having light color and good absorptive properties for the resin are preferred. The fibrous structure of the wood should be retained in some measure if the finished plastic is to possess good mechanical strength. Woodflour as a filler gives good molding properties, but tends to absorb moisture, and so to make electrical properties variable, and reduce dimensional stability.

Cotton flock—This is a by-product of the textile industry, and is obtainable in both dark and light (bleached) shades. It gives high impact resistance to the plastic, with lower mold shrinkage than occurs with woodflour-filled types, but preforming is more difficult. Water absorption and electrical properties are about the same.

Chopped fabric—Scraps of canvas duck of about 8-oz. weight are cut into pieces about ½-in. square. Impact resistance of the finished plastic is much higher than that of the woodflour-filled material—as much as 12 times as great. The material cannot be automatically preformed, however, and molding pressures must be higher. Water absorption is higher, and electrical properties poorer.

Twisted cord—Twisted cord is obtained as a by-product of the automobile tire industry, and is cut to about ½-in. lengths. Impact strength is the highest obtained in molding phenolics, being about three times that developed with the chopped fabric filler. Flow is good, but water absorption, electrical properties, and difficulty in preforming are present here as in the other fiber-filled resins.

Walnut shell flour—This filler is more expensive than woodflour, and provides about the same mechanical strength, with somewhat lowered water absorption. It produces a smooth, glossy surface in molded parts.

Inorganic fillers—Inorganic fillers in general have low water absorption, good heat resistance, good surface hardness, and good chemical resistance as their advantages. They improve dimensional stability of the molded resin. They include:

Asbestos—This material is used both in the form of long fibers and of fine powder. It has good heat resistance, chemical resistance, and low water absorption. Its cost is low. Tensile and flexural strengths are lowered, however, and the material is of comparatively high specific gravity.

Diatomaceous earth—This form of silica, of organic origin, is lighter than other naturally occurring forms of that material. It will improve the heat resistance, electrical properties, and appearance of the molded phenolic without increasing the weight as much as would an equivalent amount of asbestos. Because of its abrasiveness, it is usually mixed with other fillers so as to reduce wear on the molds and sticking of the molded pieces.

Mica—Mica confers some of its excellent electrical properties upon the plastic part in which it is used as a filler. Low power factor and low dielectric loss are characteristics of mica-filled phenolics, and the low water absorption helps to retain these properties when the part is in service. Mica is not readily wetted by the resin during molding, and especial care is necessary to insure proper coverage. Special lubricants are ordinarily used to overcome a tendency to stick in the mold. Shrinkage is low, but mechanical strength is also reduced, and specific gravity increased.

Two additional kinds of materials are usually included in the formulation for a phenolic molding compound. These are colorings and mold release agents. Nearly all molded phenolics contain a small amount of dye to give them clean, uniform color, with the exception of certain mica-filled compounds intended for electrical applications. The amount of coloring matter will be about 2 to 4% of the resin content.

When a black color is desired, carbon black, a pigment, or nigrosine, a dye, may be used. The carbon black is employed in molding compounds to be used for bottle or jar tops, where the color must not bleed in contact with alcohol or organic solvents. It is not used where electrical properties are important, as the carbon is a high-resistance conductor. For electrical applications and general purpose materials, nigrosine is used.

Brown is widely used, especially in the so-called natural color materials, and mineral pigments are the preferred coloring matter here. Some organic dyes are used also.

Colors can be used also, but as the resins themselves are somewhat dark in color, white and ivory shades are not ordinarily made. By using a white pigment along with organic dyes, and sometimes with inorganic pigments, a wide range of colors can be obtained.

Mold release agents are incorporated into the phenolic molding formulations to insure ejection from the mold cavity. The plastics material is forced into the mold under high pressure, and use of such a lubricant is necessary to facilitate release. They are used in amounts under 3% of the resin content of the compound. They are of four types: (1) mineral waxes, such as ceresin and paraffin wax; (2) vegetable waxes, including carnauba, montan, and candelilla; (3) fatty acids, usually stearic acid and oleic acid; and (4) metallic soaps, especially zinc stearate and calcium stearate.

The most important molding properties of phenolics are plasticity, cure time, specific gravity, and shrinkage. These are usually controlled from determinations of physical properties, especially granulation, apparent density, bulk factor, pourability, and moisture content, inasmuch as no chemical analytical methods give the desired information.

Plasticity is the property permitting the resin, under the effect of heat and pressure, to flow and fill the mold. While it is influenced by several variables, it is primarily dependent upon the degree of polymerization of the resin. Tests have not yet been standardized.

Cure time, the length of time the phenolic must be held in the mold under heat and pressure to complete polymerization, depends upon the type of resin, the plasticity, and the moisture content, as well as the molding temperature, cross-section of the piece, heat conductivity of the filler, and the amount of preheating.

Specific gravity refers to the property of the material in the molded form, and depends upon the type of filler used and, to a lesser extent, upon the molding pressure and type of mold used. With woodflour as filler, the specific gravity is about 1.35 to 1.39, while asbestos used alone will increase it to about 1.8. This property is important to the molder economically because he buys his material by the pound and sells his product by the piece.

Shrinkage occurs in molded phenolics to a slight extent during polymerization in the mold, and to a greater extent while the piece is cooling after removal from the mold. That occurring in the mold is usually negligible as far as final dimensions are concerned, while the shrinkage occurring upon cooling is partly due to the chemical reaction still in progress and partly to the usual contraction due to cooling. Shrinkage in these plastics is both greater in amount and more variable than in the case of metals.

Average Shrinkage Values With Various Fillers

Type	*Shrinkage, in. per in.*
High resin content	0.009 to 0.015
Woodflour-filled	0.006 to 0.008
Mineral-filled	0.0035 to 0.0045
Fabric-filled	0.003 to 0.004

Shrinkage must be known when designing a mold in which a part is to be made, and the proper allowances must be made. No mathematical expression of this shrinkage can be made because of the number and complexity of the variables involved. For material of a given composition and plasticity, shrinkage depends primarily upon molding conditions, particularly temperature, pressure, and cure time. The difference between molding temperature and room temperature results in contraction of the material upon cooling, as is the case with most solids. Reducing cure time to a minimum may cause greater than normal shrinkage, but after the optimum cure time has been reached shrinkage is no longer reduced by lengthening time of cure. Use of inadequate molding pressure will often cause high shrinkage.

Molded phenolics are resistant to alcohol, have good moisture resistance within the bounds noted, have fairly good resistance to acid attack, are decomposed by strong alkalies, and have good surface appearance. They are used for such parts as handles for cooking utensils, telephones, electrical insulators, gears, radio cabinets, and business machine cases.

For the second type of phenolic, based upon method of manufacture, the cast phenolics present many distinctive features of engineering value as well as advantages in production of consumer items. They are made over the same general formula as the other phenolics, but with variations to give them their special features.

They are phenol-formaldehyde resins, but in the case of the casting resins, polymerization takes place in open molds, at slightly elevated temperature, over a period of several days. They are frequently made without filler, and may be transparent or translucent. Polymerization is largely the result of catalysis.

A relatively high formaldehyde ratio is customary in preparing the casting phenolics. Close control of the chemistry of manufacture is necessary and especially must the use of the catalysts, basic and acid, be controlled. In the manufacturing process the following variables affect the finished product: proportion of ingredients; type of catalyst used; concentration of catalyst (pH value); time and temperature of reaction; neutralization of the catalyst; and temperature of cure.

Acid catalysts used include sulfuric, hydrochloric, phosphoric, maleic and oxalic acids; basic catalysts may be caustic soda, caustic potash, barium hydroxide, calcium hydroxide, or ammonium hydroxide.

In a typical casting resin reaction, the phenol-formaldehyde and a relatively high ratio of caustic soda, the catalyst, are heated at atmospheric

Approximate Physical Properties of Molded Phenolics

Filler	Tensile Str., Psi.	Impact Str., Ft.-Lb. per In. of Notch	Specific Gravity	Top Service Temp., F	Water Absorption % in 24 Hr.
Woodflour	7,000	0.25	1.35-1.45	275	0.5
Cotton Flock	9,000	0.50	1.35-1.45	275	0.5
Chopped Fabric	8,000	6.0	1.35-1.45	275	1.0
Twisted Cord	8,000	10.0	1.35-1.45	275	1.5
Asbestos	5,000	0.50	1.6 -2.0	350	0.25
Mica	5,000	0.35	1.6 -2.0	275	0.10

pressure at 185 F for about 22 hr., using nickel or nickel-lined equipment to avoid contamination with traces of iron. An acid catalyst may now be added to neutralize the alkali, and the moisture is partially removed by vacuum dehydration. The resin is then cast into open molds. The resin gradually sets up to form a transparent soft gel, containing the water still present as a dissolved phase. After about 16 to 20 hr., usually including heat at about 140 F, water droplets separate throughout the resin, and give the casting an opaque appearance.

When color effects are to be obtained, the color, if an organic dye, can be dissolved in alcohol, water, glycerin, etc., and incorporated into the liquid resin before finishing; if an organic pigment, it may be ground with an appropriate vehicle and added to the liquid resin. Mottled effects are obtained by stirring into the resin, after dehydration and before pouring into the molds, previously processed resin base made up with a high concentration of the proper dyes or pigments.

In the molding of cast resins, several techniques are used. The most widely used is that in which *profile* or *draw molds* are made in lead. An arbor is prepared from one or more steel or brass patterns fastened to a funnel plate. This arbor is then dipped into molten lead, and a continuous layer of lead immediately freezes around the sides of the pattern and edges of the funnel plate. The arbor is withdrawn from the lead bath and, after cooling, the lead form is drawn from the arbor. Sides of the arbor must be given a slight taper to permit easy withdrawal.

Split molds can replace the draw molds when the part requires the use of undercuts. Here multiple molded sections of lead, fitting together tightly at the parting line, are connected with a gate at the top of the mold for filling.

When a core must be used, *slush molding* may be the best method. An open lead mold similar to the draw mold is prepared, and a carefully machined insert is used to displace a portion of the resin when the core is placed. The core causes the liquid resin to rise so as to fill the mold.

Rubber molds provide an economical solution to molding problems when the part requires one or more undercut portions in the mold. A new high-melting rubber is available that may be formed in its molten state over the pattern, then stripped off after it has cooled. The resin is poured into the rubber mold so obtained, and the mold is later stripped off the hardened plastic.

Plaster, certain *plastics,* and *wood* are at times used for making molds for casting resins. *Metals* other than lead are sometimes used, but must be given a coating of acid-resisting paint if not in themselves acid resistant. Plaster must be given a coating of a parting agent, and the plastics likewise.

Sheet stock can be produced in the casting resins by *slicing,* or by *casting* directly into sheet form. Sliced sheets are made by casting a block of the resin in a tin box, curing to a firm gel, and slicing on a celluloid slicing machine. Cast sheets are poured in a gang mold consisting of spaced glass sheets, and after curing the mold is dismantled to obtain the plastics sheets. The pieces so prepared have a high luster.

Some of the advantages of cast phenolics over other types are:

(1) There is little shrinkage during the transition from the liquid to the solid state.

(2) Physical properties — tensile, impact, compressive, and flexural strength—are fairly high, and compare favorably with those of most general purpose molding phenolics.

(3) There is a minimum of exothermic reaction in the polymerization of the cast resins.

(4) Molds are inexpensive, and casting techniques permit complete freedom of design.

(5) Products are nonflammable, nonabsorbent, odorless, tasteless, and hygienic.

(6) The resins have a light color, and may range from opacity to water clear transparency, giving them an almost unlimited range of color possibilities. Effects resembling marble or onyx may be produced.

Plastic parts for the Kelvinator refrigerator are over 31 in. long and are molded on a 70-sec. cycle. They are molded of white polystyrene. (Courtesy: Hydraulic Press Mfg. Co.)

The cast phenolics are used in the manufacture of knife handles, clock cases, radio cabinets, decorative trim, costume jewelry, etc.

In the third broad group of phenolics, the laminated phenolics, there are included many of the materials that engineers think of as structural plastics. About 45% of the current production goes into various electrical insulation applications; mechanical, structural, and chemical uses take about 40%; the remaining 15% goes to decorative items.

With other types of phenolics there are variations of composition or of the manufacturing process that can be made to give emphasis to certain properties over others. The properties of the laminates are so greatly influenced by the pressure used in laminating that this is made the basis for a broad division of the group. *High pressure laminates* are formed at pressures nearly always in excess of 500 psi. and usually about 1,000 psi. *Low pressure laminates* are usually formed at pressures below 200 psi., and 100 psi. might be taken as an average. In both cases there is no theoretical limit, and no sharp boundary between the two.

While the high pressure laminates are almost exclusively phenol-formaldehyde resins or the related melamine-formaldehyde compositions, low pressure laminating has several newer types at its disposal. The laminates, therefore, cannot be considered as a complete group in a classification based upon composition types. Briefly, then, the high pressure laminates are denser, more water-resistant, generally stronger, have a smoother surface, and have

Approximate Physical Properties of Cast Phenolics

Tensile Str., Psi.	Impact Str., Ft.-Lb. per In. of Notch	Specific Gravity	Top Service Temp., F	Water Absorption % in 24 Hr.
3,000-7,000	0.40	1.3	160	1.0

Thermosetting Beetle in a wide range of colors is used in the molding of parts for this writing set and telephone index. (Courtesy: American Cyanamid Co.)

better electrical properties; they are limited to simple shapes, although some grades may be postformed. Size of the piece is limited also, due to the high total force required for large pieces. The low pressure laminates make possible the production of large pieces in presses of the size now available because of the lower unit pressures required. The surface is usually smooth on one side only, as there is frequently only one die used.

High pressure laminating makes use of conventional types of presses. The high pressures developed in the process requires that equipment of rather large size be used. Hydraulic presses are favored. For low pressure laminating some interesting equipment, borrowed from the plywood and rubber industries, is used to produce large pieces at low die cost. The methods most used are:

Bag molding—Only a single die is used, either male or female. The impregnated layers of material are placed over or in the mold, and the whole is placed in a rubber bag. Air is exhausted from the bag, pressing the layers about the mold, and the bag is then placed in an oven, or in an autoclave, to complete the cure.

Blanket molding—This is used with a female mold. The layered material is placed inside the mold, a rubber blanket is fitted into it and fastened tightly around the edges, and air is exhausted from between blanket and layers. The whole is heated by steam jacketing, or by placing in an autoclave.

Hat press molding—Used where higher pressures are necessary. Paired dies are used, but they are not accurately mated. The layers are placed in the female die, and a rubber bag is placed between the work and the male die. The dies are closed, and the rubber bag is filled with a fluid under pressure, usually steam, and held during cure.

The laminates in general, both high and low pressure, are to a great extent dependent upon the type of filler used for their physical properties. The resins themselves are supplied to the laminators as varnishes, and the filler is impregnated with the resin in this form. Impregnation may take place as the web of filler is passed into a tank containing the laminating varnish, or it may be applied by brushes or by rollers as the filler is passed through a machine. Squeeze rolls or a doctor blade remove excess varnish, and the impregnated material is dried to remove the solvent. When the filler is in the form of a mat, so that doctoring is inadvisable, the varnish can be applied by a spray.

The resin is said to be in the A stage when in solution in the varnish, and when first taken up by the filler. It is soluble and fusible. After drying in an oven, polymerization has been started, and the resin is less soluble and fusible, though still sufficiently so to permit its being fused into sheets or other forms. It is now in the B stage. In the final, or C, stage, polymerization has been carried to practical completion, and the mass is now infusible and insoluble.

The impregnated and dried sheets can be laid up as plies, with the sheets one on top of another and running in the same direction, or in cross directions, or at 45 deg. to each other. Metal sheets placed between a definite number of plies serve as spacers, and the entire mass, perhaps several feet thick, is then subjected to heat (about 300 F) and pressure (about 1,000 to 1,500 psi.) to form laminated sheets. Tubes are made up by winding the impregnated sheets onto a mandrel and baking in an oven (rolled tube), or formed in a mold (molded tube), and completing polymerization. Rods are made the same as tubes, but a small mandrel is used, and is withdrawn before placing in a mold.

Laminate Filler Materials

The material used as filler in the laminates includes:

Cotton fabric—These laminates can be postformed to compound curves. Although a wide variety of weaves and weights of cloth may be used, the most important factor is the ratio of weight of cloth to weight of resin. The heavier weights of cloth tend to give fuzzy edges when machined, but have high impact strength. Increasing the resin ratio provides better moisture resistance, and makes them suitable for electrical applications requiring good toughness. Finer weaves of fabric are used where fine machining must be done, and, with higher resin ratio, for electrical applications in which good mechanical properties are also needed.

Linen fabric—Laminates made with linen are specialty materials intended for uses where high mechanical properties are required.

Cellulose paper—The laminates can be postformed to simple curves. Several distinct materials are included in this group.

(a) Kraft paper. Has rather low moisture resistance, and impact strength below that of fabric laminates.

(b) Rag or wood alpha paper. Primarily punching stock.

(c) Multicolor stock. Several sheets with a facing sheet of contrasting color intended for engraving nameplates, etc.

(d) Mischerlich. This is a high-strength sulfite paper; general purpose.

Glass-fiber fabric—These grades cannot be postformed. While costly, they offer the highest strengths available in the laminated types. Some of the newest uses of structural laminates

Approximate Physical Properties of Phenolic Laminates

Filler	Tensile Str., Psi.	Impact Str., Ft.-Lb. per In. of Notch	Specific Gravity	Top Service Temp., F	Water Absorption % in 24 Hr.
Cotton Fabric	10,000	10.	1.3	250	1.0-8.0
Cellulose Paper	8,000-20,000	1.0- 7.0	1.3	250	1.0-8.0
Glass-Fiber Fabric	10,000-40,000	6.0	1.4-1.8	350	1.0
Asbestos Fabric	10,000	2.0-10.0	1.7	300	1.0

have taken this fabric.

Asbestos fabric—High flame resistance, good dimensional stability, superior heat resistance; variable electrical properties.

Glass-fiber mat—Recently developed as a lower-cost glass fiber laminating material. It is suggested for electrical high-frequency applications.

Asbestos mat—Properties similar to those of asbestos fabric laminates, but not as strong and tough.

Wood—Sheets of wood impregnated with resin have shown tensile strengths of about 25,000 psi.

Laminated phenolics are made up as standard materials in sheet stock, tubes, and rods. Shapes can also be obtained to special order. Laminated stock, to a larger extent than the other forms of phenolics, is bought in these standard forms and machined to shape, as are metals.

Laminated phenolics are used in table tops, gears, bearings, electrical panels, milling machine ways, refrigerator doors, etc.

Amino-Formaldehyde Resins

This group of thermosetting resins, important both industrially and in the consumer goods field, includes the melamine-formaldehyde materials and the urea-formaldehyde types. Industrially, the melamines are especially desirable because of exceptionally high arcing resistance.

Much that has been said for the phenolics is true of the amino resins also. The melamines and ureas are produced as molding compounds, with various fillers. Laminates are made with the melamines also. While casting resins are not made with either of these compositions, both are produced as liquid resins that go into beater sizing of paper to provide high wet strength, and melamine formulations are used in liquid form to treat wool, making it crease-resistant and nonshrinking.

Molding compounds are probably the best known and most widely used form for both resins. With light-colored fillers the resins can be made in all colors by the use of dyes. Both have excellent arcing resistance. Both are odorless and tasteless. Both have good strength and good surface hardness.

The fillers used:

Alpha cellulose fiber—Used in the molding of both types of resins.

Woodflour—Recently introduced as a filler for melamines.

Chopped cotton fabric—For use with melamines.

Asbestos fiber—Used with melamines.

The molding compounds are formed in the same way as has been outlined for the phenolics. Ureas are molded at high pressures, usually above 3,000 psi., and at temperatures of about 300 F or slightly higher. The melamines take the same general conditions, although pressures may sometimes be lower, because of the cleaner molding characteristics of melamines generally.

The melamines are also used to produce laminated materials. Sheet stock can be; (1) cellulose paper; (2) glass-fiber fabric; or, (3) asbestos paper. The glass-fiber laminate is especially interesting because it becomes one of the best materials for the construction of electric switch panels. It combines high strength, excellent arc resistance, good fire and heat resistance, and moderate cost.

In the field of low pressure laminating, a urea-melamine has been produced that can be formed at pressures below 50 psi.

Both of these resin types are much used in the present cold resinous glues that have revolutionized the plywood industry. The resins are supplied as a dry powder that can be mixed with water and applied similarly to ordinary glues. The resin then polymerizes at room temperature and under the usual clamping pressures, although 8 to 12 hr. may be required. By raising the temperature slightly the time will be greatly shortened. In commercial practice dielectric heating is used to heat the glue line and promote rapid polymerization, without requiring conduction of the heat through the wood layers.

The aminos are used in electrical applications, as indicated, and in scale housings, light shields, toiletry containers, buttons, tableware, etc.

Approximate Physical Properties of the Aminos

	Filler	Tensile Str., Psi.	Impact Str., Ft.-Lb. per In. of Notch	Specific Gravity	Top Service Temp., F	Water Absorption % in 24 Hr.
Molding Powders	Chopped Alpha Cellulose	8,000	0.30	1.50	220	0.5
	Chopped Cotton Fabric	8,000	0.7	1.4	250	0.5
	Asbestos Fiber	6,000	0.7	1.8	270	0.1
Laminates	Cellulose Paper	10,000-20,000	0.5-1.5	1.5	225	2.0
	Glass-Fiber Fabric	20,000-25,000	10.0	1.9	—	1.0
	Asbestos Paper	7,000-10,000	1.0	1.8	240	2.0

Aniline-Formaldehyde Resins

The essential reactions in the aniline-formaldehyde condensation were discovered in Germany during the latter part of the 19th century. It is produced in a number of formulations, some of which are interesting because they show a gradation of thermoplastic and thermosetting properties.

When the mix is prepared with the aldehyde content rather short, a fusible material resembling hard rubber is produced. This plastic can be softened by heat and molded as can the thermoplastics, though the molding temperature is above 300 F. The material is still quite viscous at this temperature, and pressures above 1,500 psi. are necessary. When heated to still higher temperatures, the resulting piece tends to be brittle.

Increasing the formaldehyde content produces a truly thermosetting resin. This is the material most used. It possesses as one of its valuable properties good electrical insulating properties, especially for ultrahigh-frequencies. It is attacked by strong acids, but resists action of alkalies and of the organic solvents. The material is of a reddish-brown color, and can be dyed in dark colors only. It has good moisture resistance, even when used outdoors, and so can maintain its electrical properties.

While the aniline-formaldehyde resins are largely used without filler, they can be used with cellulose or asbestos fibers. Use of a filler reduces the moisture resistance, and hence the electrical stability of the plastic.

The resin has good mechanical strength. It has been successful in various electrical applications for aircraft radio, such as coil forms and antenna housings. Its good electrical

properties at ultrahigh-frequencies recommend it for use in television.

In addition to the uses mentioned, it finds application in terminal boards, tube bases, outside insulators, test equipment, etc.

Allyl Ester Copolymers

One of the newest of the thermosetting plastics is an allyl ester recently offered to industry. Its exact composition has not yet been revealed, and its physical properties have not been determined fully, but it is a copolymer of esters of allyl alcohol, and can be produced in an almost perfectly water clear form. It has good strength properties insofar as tests have yet gone. The upper limit of service temperatures has not yet been fixed, but it will be above 300 F, as the resin is cured at higher heats than this.

A field in which the allyl esters are expected to produce interesting results is low-pressure laminating. Allyl resins polymerize without splitting off water, and the reaction may proceed at contact pressures. The cost of the resin is still high, and it cannot compete with general purpose materials, but its hardness, chemical resistance, and ability to polymerize without the necessity of evaporating a solvent or driving off water liberated by the reaction make it potentially valuable for the low-pressure laminating industry.

Being thermosetting, it has good dimensional stability when used without filler. The new resin has been tried for optical uses, and has been found capable of taking and keeping the accurate grinding and high polish necessary for prisms and lenses. It is probably the most glasslike of the plastics, with a hard surface that resists scratching better than the other water-clear plastics. The first allyls showed a tendency to develop a yellowish cast upon aging, but the most recent materials have largely overcome this handicap.

The allyls have good resistance to deterioration at elevated temperatures, and good flame resistance. Moisture resistance is excellent, and it is impervious to attack by most organic solvents. Alkalies have practically no effect upon it, but some strong acids will attack the resin.

Use of the allyl resins waits upon a price reduction to competitive levels. In the meantime it has gone into optical work to a limited extent, and some costume jewelry has utilized its transparency and color.

The Thermoplastic Resins

Cellulosics

The cellulosics are the most important molding compounds among the thermoplastic resins, and one of the most versatile and most widely used of all the plastics. They are familiar as industrial materials in the form of sheets, rods, and tubes; they go to the molder as molding powders; they include some of the synthetic textile fibers; they are valuable materials in that field taking the greatest amounts of plastics, the protective coatings; as film and foil they go into packaging and other lines.

The cellulosics came in on the ground floor of the plastics industry. As has been pointed out, the first of the modern plastics was a cellulose material, celluloid. Its combustibility made it dangerous for many uses where high heat or an open flame might be encountered, and a new cellulosic was produced in 1910 as a less flammable photographic film base. As this was about the same time that the first of the phenolics was being produced, it can be seen that the cellulosics were staying in the field. The new material, cellulose acetate, has remained one of the most widely used of the family.

The cellulosics are fortunate in having a plentiful source of raw material, renewable each year, in cotton. They are made from the short fibers of cotton, called linters, that cannot be spun to good advantage, and so might be thought of as a by-product of the textile industry. This supply is reinforced with specially purified grades of wood pulp (the dissolving pulps).

As the first step in the manufacture of all of them, the cellulose, whether cleaned cotton linters or wood pulp, is dissolved in a chemical bath. In the case of celluloid, this chemical bath is nitric acid, with sulfuric acid to take up the liberated water. A cellulose nitrate results. When properly washed and dehydrated, and treated with a plasticizer, camphor, this forms the basis for a whole series of pyroxylin materials, ranging from molded objects to coatings for cloth and lacquer bases.

If acetic acid is the essential chemical in the dissolving bath, cellulose acetate is produced. When both acetic and butyric acids are used, cellulose acetate butyrate is formed. Propionic acid gives cellulose propionate, and use of a mixture of caustic soda and ethyl chloride produces ethyl cellulose. All are much-used plastics.

Cellulose nitrate has the distinction of being the toughest of the thermoplastic resins, in addition to being the first. Its valuable properties have kept it in the race with newer materials, so that today, with practically every one of its original applications lost to it, it is being produced in larger quantities than ever before.

In its manufacture, cotton linters are cleaned and treated with a mixture of nitric and sulfuric acids. When nitration of the cotton has proceeded sufficiently far to produce a material that contains about 11% nitrogen, the acid is drawn off, the material is treated with boiling water, then dehydrated with alcohol under pressure. The cellulose nitrate is then worked in mixers and rolls while still wet with the alcohol, and camphor is added. Coloring may be added at this stage also, if desired.

If the material is to be made into sheets, slabs from the rolls are pressed into cakes, then cut into sheets, and the sheets are allowed to age for a considerable period of time to permit the removal of the remaining solvent. Tubes or rods, or continuous sheet, can be formed by extruding the mass from the rollers, and afterwards aging to remove remaining solvent.

The finished plastic is easily machined by all the standard processes. It can be formed easily when warmed, and can be blown into molds from sheet stock to form hollow objects. Compression and injection molding give more difficulty. It can be produced in all colors, and in all degrees of opacity from transparent to opaque. Direct sunlight seems to cause rapid yellowing, however. It is easily cemented to itself and to other materials.

Cellulose nitrate is used for fountain pens, toothbrushes, handles for small

tools, mallet heads, spectacle frames, drawing instruments, toys, wet-cell battery cases, etc.

Cellulose acetate, the second of the cellulosics to be developed, offered an answer to the two most serious problems associated with celluloid. The new material was more flame-resistant, and did not discolor when exposed to sunlight. One of the important uses of cellulose nitrate had been in the production of laminated glass for automobiles, but its tendency to discolor was a serious defect. A few years after cellulose acetate sheet appeared, in 1927, it was tried as the interliner in safety glass, and soon won practically a monopoly. It has since been replaced by other thermoplastics.

The resin is made by the action of acetic acid and acetic anhydride upon cellulose, with sulfuric acid to take up liberated water. A compound of cellulose is formed that exists as a thick liquid until water is added, when it decomposes, precipitating cellulose acetate. The acetate is washed and dried, and is used for preparing the plastic in usable form.

For making sheet or film, the dried plastic can be mixed with a plasticizer, color added if desired, and the mass worked on a hot roll. The plasticizer usually will be an organic liquid of high boiling point that has some solvent action upon the acetate. The slabs from the roll are pressed into cakes, cut into sheets, and seasoned, or it can be cut into granule form.

A second process requires that the dried acetate be moistened with alcohol and acetone to soften it, then thoroughly mixed with the solvents, and rolled out on warm rolls to form a slab. Colors are added during the rolling if desired. The slab can be pressed into cakes, cut into sheets, and seasoned to permit evaporation of the remaining solvent; for rods and tubes, it can be extruded to size and shape desired, and seasoned; for molding powders, it can be ground to the correct size in a knife mill.

Sheet stock can also be prepared by extruding the rolled slab through a long, narrow orifice.

Cellulose acetate can be molded by compression or injection molding. *Compression molding* has been mentioned in connection with the processing of thermosetting resins, for which it is the only molding method available. It is equally useful for the thermoplastic resins. In this method, the plastic is placed in a preheated die, the two halves of which then close, fusing the resin and causing it to fill out the die cavity. When thermosetting materials are being molded, the mold must remain closed, with heat and pressure applied, until the resin has been cured (polymerization advanced to practical completion). With the thermoplastic materials the mold must remain closed also, but heat is withdrawn instead of being applied during this waiting time, so that the shaped material may be chilled sufficiently to retain its shape when taken from the mold. This makes the molding cycle longer for the thermoplastic materials.

A variation of the compression molding process is known as *transfer molding,* and speeds the process for thermosetting resins by preheating the material.

Injection molding can be used with the thermoplastic resins only. It uses unheated dies, and the resin is heated to plasticity in a separate heating chamber. The heated material is then injected into the die cavity, where it is chilled sufficiently to set-up almost at once by contact with the relatively cold metal dies.

Injection molding is much more rapid than the compression method. By feeding the molding powder from a hopper in automatically measured charges, and providing for automatic ejection of the molded pieces from the dies, operation of the machine can be made completely automatic. There is, therefore, less handling of the material and product. It is limited as to the size of the piece that can be produced, with the charge of molding powder held to a maximum of about 2 lb. Compression molding can be used for larger pieces, and more complicated pieces, and those with heavier wall thicknesses, can be made.

Extrusion of thermoplastics follows the general plan of operation used in extruding of metals. Equipment is much lighter, and the heating of the material to plasticity takes place just before it is forced through the extruding die. The plastic is fed into the machine as a granulated material, and is carried to the heated section of the press by a screw conveyor. Here heating is accomplished, and the softened resin is extruded onto a conveyor.

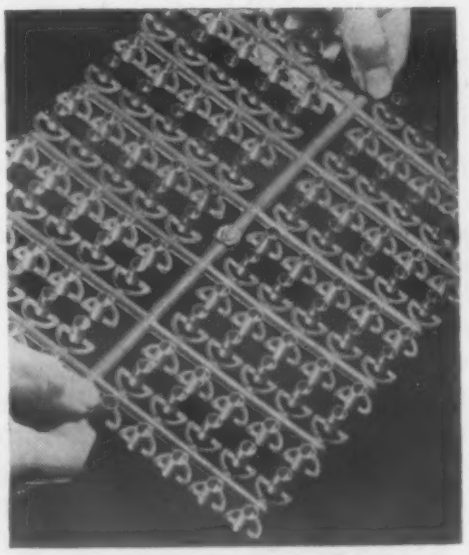
Cellulose acetate has good strength characteristics, good toughness and low moisture absorption, and shows dimensional stability at ordinary temperatures. An additional property that is utilized commercially is the high transmission of the clear material for ultraviolet light. This is made use of in plastic glazing for greenhouses and hatcheries. Its freedom from distortion of light when used as an eyeshield has given it a prominent place among the safety materials. The same property makes it of value for flashlight lenses, models, and as a transparent protective covering for blueprints and the like.

Other uses include transparent or decorative packaging, tags and buttons, electrical insulation, paint brush bristles, toilet accessories, small kitchen utensils, spectacle frames, etc.

Cellulose acetate butyrate is a more recent member of the cellulosics family, but a successful and widely used one. It resembles the cellulose acetate in general properties and in method of manufacture, but, because it is a mixed product, its properties are capable of regulation by varying the proportions of its constituents.

The preparation of cellulose acetate butyrate follows the plan for making the acetate, except that both butyric and acetic acids and anhydrides are used instead of the acetic compounds alone. The resulting material is more soluble in organic solvents than the acetate, and is more readily plasticized. Another feature of the plasticized materials is that they have better moisture resistance than the acetate plasticized resins. This makes them valuable for lacquers and coatings.

A property of the mixed material



Tenite pencil ferrules are produced at a rate of 120 in a single casting through injection molding. (Courtesy: Tennessee Eastman Corp.)

Approximate Physical Properties of the Cellulosics

Resin Type	Approximate Tensile Str., Psi.	Impact Str., Ft.-Lb. per In. of Notch	Specific Gravity	Top Service Temp., F	Water Absorption % in 24 Hr.
Cellulose Nitrate	5,000-10,000	3.0- 8.0	1.4	140	1.0-3.0
Cellulose Acetate	4,000- 7,000	3.0	1.3	130	3.0
Cellulose Acetate Butyrate	2,000- 6,000	1.0- 9.0	1.2	140	1.5
Cellulose Propionate	3,000- 6,000	1.0-11.0	1.2	135	1.4
Ethyl Cellulose	3,000-10,000	1.0-11.0	1.1	140	1.5

that is important to the users of molded parts is their sharp breaking fluidity. They soften only slightly as they are heated until a critical temperature is reached, its value depending upon the composition of the resin, when fluidity increases considerably with only slight increase in temperature. This gives the molded parts good resistance to distortion at somewhat elevated temperatures, but permits molding at relatively low pressures by careful selection of molding temperatures.

A disadvantage of the cellulose acetate butyrates is that they have an unpleasant odor, and may impart an off taste to food or water in contact with them over a period of time. This can be reduced to a considerable extent by thorough washing.

The mixed ester plastic can be molded by either the injection or the compression methods, can be continuously extruded, is readily machined with ordinary tools suitable for wood or metal, or can be cast. Its readiness to take up plasticizers is utilized in a number of gel coatings in which an amount of solvent and castor oil sufficient to produce a thick gel is added to the resin, and the mixture used as a dip coating to give protection during storage and shipping to metal parts. The coating can be stripped off when its protective function has been completed, and can be remelted and reused.

Cellulose acetate butyrate can be produced in transparent form, and in a wide range of colors. The cast resins have been used for the production of short-run forming tools, punches, and draw dies. Molded materials have produced football helmets, knife handles, building hardware, whistles, gunstocks, etc. Coating compositions are being used on metal, and on many nonmetallics. Thin foil goes into electrical insulation, and into packaging.

Cellulose propionate is the newest of the cellulosics to be introduced to industry. It has excellent molding properties, and is used primarily in the form of molding powder, by injection or sometimes by compression molding. It can be used in the form of sheets and films also.

This thermoplastic has low moisture absorption, and good dimensional stability. It has shown good toughness, and is readily compatible with plasticizers to permit variation in physical properties when desirable. Because the resin has naturally good plasticity, less than the usual amount of plasticizer is needed with it as compared with cellulose acetate. Molded pieces take a high finish, and do not ordinarily require polishing. Both light and dark colors can be used.

The formative reaction for cellulose propionate is like that for the other cellulose plastics, but with propionic acid and propionic anhydride reacting upon the cellulose in the presence of a catalyst. Unlike the cellulose acetate butyrate, the odor of the acid constituent cannot be noticed in the finished plastic.

In addition to possessing excellent molding qualities, the resin can be extruded successfully. It can be machined with ordinary metalworking tools, and cuts well at high speed if the temperature is not permitted to rise to levels at which the material tends to soften.

Cellulose propionate is being used for the manufacture of telephones, containers, electrical insulation, flashlight cases, radio parts, etc.

Ethyl cellulose, another new member of the family of cellulosics, differs from the others chemically in that it is not an ester of cellulose, but a complex ether. It has the distinction of being the lightest of the group, with a specific gravity only slightly greater than that of water. Its industrial possibilities were first recognized in Germany in 1912, but its production in quantity did not start until about 25 years later.

Ethyl cellulose is produced by the action of strong caustic soda upon cellulose, and by treating the resulting product with ethyl chloride. Variation in the conditions of the original treatment with caustic, and of the substituting reaction with the ethyl compound, control the amount of ethyl substitution that occurs, and the properties of the end product. The materials having the highest percentages of ethyl will mix more readily with modifiers and plasticizers, and with other resins, while those of lower content are tougher, and have superior low temperature impact strength.

The range of formulations made possible by compounding with waxes, natural resins, and such organic solvents as the alcohols, ethers, ketones, and aromatic hydrocarbons, made possible such diverse materials as strip coatings for metal protection, lacquer bases, flexible films, and hard molded objects. It can be produced in all colors and in water-clear grades.

General properties for the ethyl celluloses are good electrical insulation, low water absorption, good dimensional stability, high impact strength, good toughness, and light weight. It can be molded in compression or injection presses, though the pressures required are rather high. Extruding can be accomplished also. It can be machined without difficulty with the ordinary metal or woodworking tools.

Ethyl cellulose has better chemical resistance than the other members of the group. It will resist attack by most alkalies, but is attacked by acids.

This cellulosic is used for flashlight cases, dairy equipment, jigs and fixtures, containers, hose nozzles, decorative trim, refrigerator parts, electrical items, etc.

Vinyls

This family of plastics is one of the newest, best known, and most versatile in the industry. Just beginning to achieve commercial recognition at the outbreak of the war, they had grown to be the most used of all the plastics, in terms of value of product, by the end of the conflict. Not only did they have the greatest output, in terms of dollar value, but they rolled up a volume about two and one-half times that of their nearest competitor.

A large part of this stupendous volume went into military goods. The demand for rainwear and tarpaulins, at a time when rubber was a critical material for all sorts of war needs, was largely met by coating fabrics with

Table of Trade Names of Plastics Materials

Composition Type	Trade Name	Manufacturer or Supplier
Phenol-formaldehyde	Bakelite	Bakelite Corp., New York City
	Formica	Formica Insulation Co., Cincinnati
	Micarta	Westinghouse Electric Corp., Pittsburgh
	Synthane	Synthane Corp., Oaks, Pa.
	Durez	Durez Plastics & Chemicals, Inc., No. Tonawanda, N. Y.
	Textolite	General Electric Corp., Schenectady, N. Y.
	Resinox	Monsanto Chemical Co., Springfield, Mass.
	Aqualite, Phenolite	National Vulcanized Fiber Co., Wilmington
	Farlite	Farley & Loetscher Mfg. Co., Dubuque, Iowa
	Dilecto, Celeron	Continental-Diamond Fibre Co., Newark, Del.
	Panelyte	St. Regis Paper Co., New York City
	Insurok	Richardson Co., Chicago
	Catalin	Catalin Corp., New York City
	Spauldite	Spaulding Fibre Co., Tonawanda, N. Y.
	Lamicoid	Mica Insulator Co., New York City
	Heresite	Heresite Chemical Co., Manitowoc, Wis.
	Haveg	Haveg Corp., Newark, Del.
	Durite	Durite Plastics, Philadelphia
	Marblette	Marblette Corp., Long Island City, N. Y.
	Neillite	Watertown Mfg. Co., Watertown, Conn.
	Makalot	Interlake Chemical Corp., Cleveland
	Co-ro-lite	Columbian Rope Co., Auburn, N. Y.
	Duraloy	Fabricon Products, Inc., Detroit
	Kysite	Keyes Fibre Co., Waterville, Me.
	Ohmoid	Wilmington Fibre Specialty Co., East Wilmington, Del.
	Gemstone	A. Knoedler Co., Lancaster, Pa.
	Avtex	Hood Rubber Co., Watertown, Mass.
	Indur	Reilly Chemical Corp., New York City
	Ryertex	Jos. T. Ryerson & Son, Inc., Chicago
	Ucinite	Ucinite Div., United-Carr Fastener Corp., Newtonville, Mass.
Phenol-furfural	Durite	Durite Plastics, Philadelphia
Urea-formaldehyde	Bakelite	Bakelite Corp., New York City
	Plaskon	Plaskon Div., Libbey-Owens-Ford Co., Toledo
	Beetle	American Cyanamid Co., New York City
	Uformite	Resinous Products & Chemical Co., Philadelphia
Melamine-formaldehyde	Melmac	American Cyanamid Co., New York City
	Plaskon	Plaskon Div., Libbey-Owens-Ford Co., Toledo
	Catalin	Catalin Corp., New York City
	Resimene	Monsanto Chemical Co., Springfield, Mass.
Aniline-formaldehyde	Dilectene	Continental-Diamond Fibre Co., Newark, Del.
	Cibanite	Ciba Products Corp., Hoboken, N. J.
Allyl	Kriston	B. F. Goodrich Chemical Co., Cleveland
Cellulose Nitrate	Celluloid	Celanese Plastics Corp., New York City
	Pyralin	E. I. du Pont de Nemours Co., Inc., Arlington, N. J.
	Nitron	Monsanto Chemical Co., Springfield, Mass.
	Nixon CN	Nixon Nitration Works, Nixon, N. J.
	Hercules	Hercules Powder Co., Wilmington
Cellulose Acetate	Tenite I	Tennessee Eastman Corp., Kingsport, Tenn.
	Lumarith	Celanese Plastics Corp., New York City
	Plastacele	E. I. du Pont de Nemours Co., Inc., Arlington, N. J.
	Bakelite	Bakelite Corp., New York City
	Fibestos	Monsanto Chemical Co., Springfield, Mass.
	Chemaco	Chemaco Corp., Berkeley Heights, N. J.
	Hercules	Hercules Powder Co., Wilmington
	Nixon CA	Nixon Nitration Works, Nixon, N. J.
Cellulose Acetate Butyrate	Tenite II	Tennessee Eastman Corp., Kingsport, Tenn.
Cellulose Propionate	Forticel	Celanese Plastics Corp., New York City
Ethyl Cellulose	Ethocel	Dow Chemical Co., Midland, Mich.
	Lumarith E. C.	Celanese Plastics Corp., New York City
	Hercules	Hercules Powder Co., Wilmington
	Chemaco	Chemaco Corp., Berkeley Heights, N. J.
	Nixon EC	Nixon Nitration Works, Nixon, N. J.
Polyvinyl Alcohol	Resistoflex	Resistoflex Corp., Belleville, N. J.
	Elvanol	E. I. du Pont de Nemours Co., Inc., Arlington, N. J.
Polyvinyl Acetate	Vinylite	Bakelite Corp., New York City
	Elvacet	E. I. du Pont de Nemours Co., Inc., Arlington, N. J.
Polyvinyl Formal	Formvar	Shawinigan Products Corp., New York City
Polyvinyl Acetal	Alvar	Shawinigan Products Corp., New York City
Polyvinyl Butyral	Butvar	Shawinigan Products Corp., New York City
	Butacite	E. I. du Pont de Nemours Co., Inc., Arlington, N. J.
	Saflex	Monsanto Chemical Co., Springfield, Mass.
	Vinylite	Bakelite Corp., New York City
Polyvinyl Chloride	Vinylite	Bakelite Corp., New York City
	Geon	B. F. Goodrich Chemical Co., Cleveland
	Chemaco	Chemaco Corp., Berkeley Heights, N. J.
	Tygon	U. S. Stoneware Co., Akron

(Continued on page 134)

Table of Trade Names of Plastics Materials

Composition Type	Trade Name	Manufacturer or Supplier
Polyvinyl Chloride Acetate	Tygon	U. S. Stoneware Co., Akron
	Vinylite	Bakelite Corp., New York City
	Chemaco	Chemaco Corp., Berkeley Heights, N. J.
Vinyl Chloride Vinylidene Chloride Copolymers	Saran	Dow Chemical Co., Midland, Mich.
	Geon	B. F. Goodrich Chemical Co., Cleveland
Methyl Methacrylates	Lucite	E. I. du Pont de Nemours Co., Inc., Arlington, N. J.
	Plexiglas	Rohm & Haas Co., Philadelphia
Polyamides	Nylon	E. I. du Pont de Nemours Co., Inc., Arlington, N. J.
Polystyrenes and Copolymers	Cerex, Lustron, Styramic, Styron, Styraloy	Monsanto Chemical Co., Springfield, Mass.
		Dow Chemical Co., Midland, Mich.
	Bakelite	Bakelite Corp., New York City
	Loralin	Catalin Corp., New York City
Polystyrenes and Copolymers	Textolite	General Electric Co., Schenectady, N. Y.
	Chemaco	Chemaco Corp., Berkeley Heights, N. J.
	Tygon	U. S. Stoneware Co., Akron
Polyethylene	Polythene	E. I. du Pont de Nemours Co., Inc., Arlington, N. J.
	Bakelite	Bakelite Corp., New York City
Polytetrafluoroethylene	Teflon	E. I. du Pont de Nemours Co., Inc., Arlington, N. J.
Caseins	Ameroid	American Plastics Corp., New York City
	Galorn	George Morrell Corp., Muskegon, Mich.
Silicones	Dow-Corning Silicones, Silaneal	Dow-Corning Corp., Midland, Mich.
	G-E Silicones, Dri-Film	General Electric Co., Schenectady, N. Y.

a thin sheet of one of the vinyls. The resulting sheet was as flexible as canvas, completely waterproof, and did not deteriorate upon exposure to sunlight.

Although some of them are molding compounds producing rigid pieces, it is as rubbery, often transparent materials that the group is best known to the public. These materials usually have excellent water resistance, and good chemical resistance as well, so that they have become valuable as replacements for rubber not only to the public, but to industry also. They are important as coatings for other materials, especially textiles and paper.

Most members of the group can be prepared in this elastomeric form, but there is considerable variation in properties. The first one listed here, polyvinyl alcohol, is soluble in water; others are extremely water-resistant. Some are hard molding materials; others are tough and flexible; still others are soft gels or coatings. Those resins that are used only in the textile or paper industry as coatings will be ignored or mentioned briefly here. Many of the materials that go into coatings can by change of formulation be used otherwise, however.

Polyvinyl alcohol is prepared by hydrolysis of polyvinyl acetate, and the conditions under which the hydrolysis takes place have an important bearing upon the properties of the finished material. When completely hydrolyzed the alcohol is soluble in hot water, and is used to coat or impregnate textiles, paper, leather, etc. It possesses good grease resistance, and resists the action of solvents also. It can be obtained in a range of viscosities, and the rate of penetration into the substance being coated decreases with increase in viscosity.

The partially hydrolyzed resin can be plasticized with various solvents, and can be molded. It takes up moisture from the air, and is not suitable for use where resistance to moisture is a required condition. It is impermeable to gases, and has good abrasion resistance. It may be prepared to have adhesive properties, especially as a remoistenable adhesive.

Polyvinyl alcohols are used in clothing for chemical workers; coatings for paper, textiles, and leather; adhesives; flexible tubing, etc.

Polyvinyl acetate is another of the vinyl group that can be changed in form by compounding so that it may appear as a molding compound, as a flexible material, as an adhesive, or as a coating. As it is odorless and tasteless, it finds use as an adhesive in the manufacture of food containers. It is also used in adhesives for bonding miscellaneous materials.

The plastic is prepared by the reaction of acetylene and acetic acid in the presence of a catalyst, and the polymerization of the resulting ester. It is lightweight and colorless, has better water resistance than the polyvinyl alcohol compositions, dissolves in many organic solvents, and is compatible with a number of plasticizers to produce a flexible material. It is slow-burning and nontoxic. Water emulsions can be prepared, and these find use in the coating of paper and textiles.

When filler is added to the resin, it becomes a molding compound having good strength, and with flow characteristics suiting it for producing intricate shapes. Molding is done at 225 to 275 F, and under pressures of 1000 psi. and higher. Because the resin distorts when heated, the dies must be kept closed and under full pressure until the material has cooled to room temperature.

An outstanding property of the polyvinyl acetates is the readiness with which they can be made to adhere to many different substances. As adhesives, they are used to bond metals, cloth, porcelain, wood, glass, paper, and other plastics.

In addition to the uses given, polyvinyl acetate is used as a finish for leather, as a base for lacquers and inks, as a sizing for cloth or paper, etc.

Polyvinyl acetals include several materials used to a considerable extent as coatings, laminating resins, and in enamels and primers. They are produced by the reaction of polyvinyl

alcohol and an aldehyde. Polyvinyl alcohol and formaldehyde produce *polyvinyl formal,* the same alcohol and acetaldehyde give *polyvinyl acetal,* and when butyraldehyde is used in the same reaction the product is *polyvinyl butyral.* Properties of the three materials are rather similar, and their uses also fall into the same general fields.

Polyvinyl formal is a colorless resin, used to some extent as a molding compound. Its greatest field of application has been in coatings and impregnating compounds, and it has been especially useful in an insulating enamel for wire. Lacquers have been based upon this resin. It is insoluble in most of the common organic solvents.

The second of the group, polyvinyl acetal, also is used as a molding material and as a coating and impregnating resin. It can be injection or compression molded without difficulty, and gives a transparent yellowish solid, resistant to many organic solvents but soluble in the usual lacquer vehicles.

As a solid resin it goes into the manufacture of some of the newer kinds of phonograph records, and is sometimes used for photographic film. Lacquers and adhesives, and surface coatings and impregnants, take up a large share of the production.

Polyvinyl butyral, the third member of this group, is the one most used in industry. It is the plastic now used in the interlayers of safety glass, where its clear transparency, and stability when exposed to light and heat, with its adhesiveness and moisture resistance, has caused it to replace other plastics for that purpose.

Like the other alcohol-aldehyde polymers, it is versatile. Different formulations can be used in adhesives, coatings, laminations, molding compounds, and lacquers. The coatings are stain-resistant, water-repellent, remain flexible at low temperatures, and resist scuffing. For certain types of coatings where elevated temperatures will be encountered it has been found possible to blend the polyvinyl butyral with ureas or phenolics, and so raise the temperature at which softening would occur.

During the war the grades of polyvinyl butyral used for laminated glass were used successfully to laminate the clear acrylics used in fighting planes. The plastic is soluble in many organic solvents, has fairly good alkali resistance, but is attacked by acids.

Polyvinyl chloride is produced by the reaction of acetylene and hydrochloric acid gas, and the pressure polymerization of the resulting vinyl chloride. It is a colorless, tough, hornlike material, resistant to moisture, to concentrated acids and alkalies, insoluble in most organic solvents, will not support combustion, and is superior to rubber in resistance to deterioration by sunlight and oxidation. It can be plasticized to a flexible condition, in which it fills many needs formerly met by rubber.

The type and quantity of plasticizer used determines to a large degree the condition of the resulting plastic. By adding sufficient plasticizer, polyvinyl chloride can be produced in flexible films and sheets of rubberlike plastic; with less plasticizer it becomes a tough, leathery material; still less makes it a molding compound, usually with filler added. It can also be prepared as a dispersion in water or other vehicle, and in this form is useful for coating or impregnating paper or fabric. In another form it can be supplied as a solution of resin in a volatile solvent, and so applied as a coating, or used to prepare a film by running the solution onto a flat surface and removing the solvent by evaporation.

It is used for shoe soles, extruded belts and suspenders, gaskets, wire insulation, flexible tubing, rainwear, chemically resistant fabric coatings, and toys and novelties.

Polyvinyl chloride-acetate is prepared by polymerizing vinyl chloride and vinyl acetate together in the presence of a solvent and a catalyst. The proportions of the two esters used can be varied widely, and the properties of the finished plastic influenced in this way. In the present copolymers, the content of polyvinyl chloride is 80% or higher.

As is the case with the other vinyls, the chloride-acetate copolymers are extremely versatile. They are produced as molding powders, as standard extrusions, as dispersions for coatings for fabrics, as flexible sheet or other forms, as solutions for coatings or film casting, and as adhesives. The flexible forms may serve as replacements for rubber, while the clear rigid sheets may perform for glass. Parts can be injection molded, but pressures required for flow of the material are high. Coatings applied to fabrics, paper, etc., from solution are unusually tough.

The resin is colorless, odorless, and tasteless; nonburning, nonwarping, with excellent water and chemical resistance, and good electrical properties. They can be molded, extruded, blown, machined, laminated, or cemented. All colors can be obtained by use of the proper dyes or pigments.

The material is used for unbreakable phonograph records, shoe soles, unbreakable watch crystals, belts and suspenders, drawing instruments, instrument dials, packaging, bottle closures, etc.

Vinyl chloride-vinylidene chloride copolymers resemble the copolymers of the chloride and acetate, but are more soluble and hence more easily applied. They are more plastic, and so more easily molded. The same wide variation of forms of the resin, and of its properties, is possible by adjusting proportions of the copolymers, and of the plasticizers after polymerization.

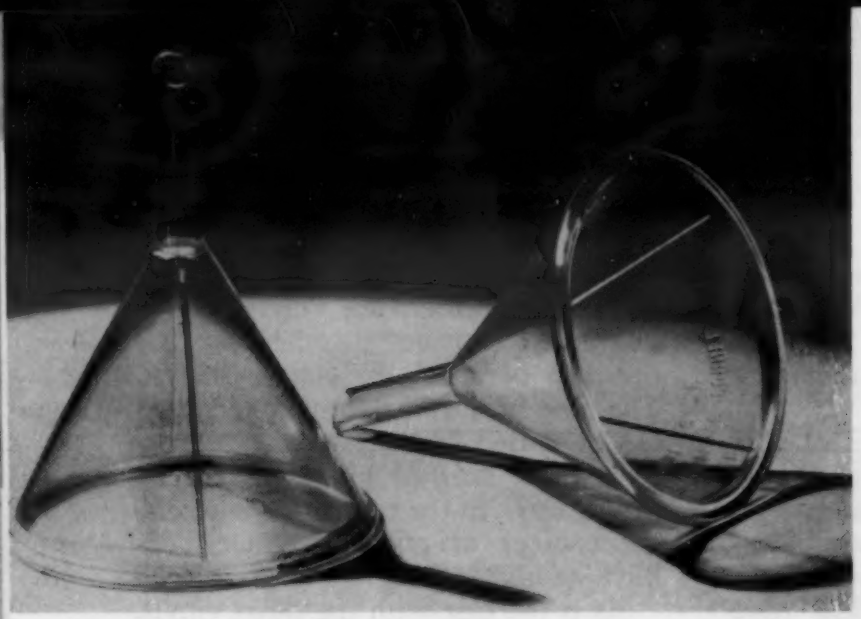
An additional feature of the vinyl-vinylidene resins is that they are compatible with certain synthetic rubbers. Blends of these materials have been prepared commercially, and have been adopted for such purposes as upholstery, in which they serve as a leather substitute. Industrially, they provide a material for a chemically resistant tubing having better flexural strength, tear resistance, and better resistance to deterioration by sunlight and air than the synthetic rubber alone.

The copolymer in solution or in latex form is used for coating fabrics

Approximate Physical Properties of Vinyls

Resin Type	Tensile Str., Psi.	Impact Str., Ft.-Lb. per In. of Notch	Specific Gravity	Top Service Temp., F	Water Absorption % in 24 Hr.
Polyvinyl Alcohol	1,000-4,000	—	1.25	—	Very high
Polyvinyl Chloride	3,000-9,000	—	1.35	160	0.3
Polyvinyl Chloride Acetate	1,000-8,000	0.4*	1.25-1.50	140	0.1
Vinyl-Vinylidene Chloride Copolymers	3,000-6,000	—	1.70	160	Very small

* *Not for elastomers.*



Plastic funnels such as these made of Lustron are highly satisfactory for many uses. (Courtesy: Plastics Div., Monsanto Chemical Co.)

and paper. When molded or extruded it is used as tubing, acid dippers, valve seats, nozzle tips, etc.

Acrylics

Although there are several compositions in this family of plastics, only one is of commercial importance. This is the polymerized methyl methacrylate that has become familiar to everyone as beautifully tinted toiletware, as gun turrets in warplanes, and as edge-lighted novelties or instruments.

The methyl methacrylate plastics are valuable engineering materials, however, in addition to being attractive in appearance. Their transparency is utilized in models of parts or mechanisms in which it is desired to study interiors. Their excellent electrical properties and moisture resistance have made them useful for outdoor electrical insulators. They have gone into chemical equipment, nonshatterable light shields, drawing instruments, and many others.

These resins are produced in plasticized form, and as solutions and emulsions. An important fabrication technique consists of casting with the liquid unpolymerized material, and polymerizing in finished form by application of heat. Use of a combination of unpolymerized and polymerized material for casting has become one of the standard techniques of the dental profession in fitting false teeth. It can be molded by the compression method. Adhesives for joining rubber and metal tubing, or for sealing gaskets when chemical resistance must be high, make use of another formulation of these resins.

Polymethyl methacrylate has excellent resistance to the action of alkalies, and good resistance to the action of many acids. This makes it of value for fittings in the chemical industry, and for chemical containers. Body tissues tolerate it well, and it has gone into plastic surgery.

Undoubtedly its most useful property is its remarkable transparency. It is one of the few plastics that has been used for optical lenses, and the only one to achieve any large scale applications in that field. It has been utilized in the optical systems of prism binoculars, and has become a standard material for television lenses. Safety shields for workers, and machinery models for study, are other industrial uses. Gage glasses, dial covers, and lightweight transparent enclosures in general have made use of the methyl methacrylates.

The resins are prepared by treating an acetone compound with methanol in the presence of sulfuric acid, and polymerizing the resulting methyl methacrylate. Heat, light and oxygen serve as polymerizing accelerators.

In addition to the uses already mentioned, the resins are used in surgical instruments, furniture displays, architectural trim, cosmetic boxes, etc.

Polyamides

These are the well-known nylons. A whole family of these interesting plastics exists, including materials suitable for extruding into filaments, molding powders, and some resins for coatings. The greatest volume of the material now being produced goes into the textile filaments, but the molding powders are showing a steady gain. Extruded tubes, and filaments for purposes other than textiles, are also important industrially.

The nylon filament was the first synthetic competitor of silk that closely resembled silk chemically. It best earned the designation "artificial silk," so generally bestowed upon the rayons and their successors. Nylon is produced by the reaction of polybasic organic acids (usually dibasic) and polyfunctional amines (usually diamines), so controlled that long-chain polymers predominate. As much as possible, cross-linkages are avoided. A variety of resins can be produced by varying the acid or amine used, or the proportions of each, or the conditions of polymerization.

The result is a chemical compound in many ways similar to the natural proteins in its composition. It is slow-burning, very tough, with good tensile strength, takes colors with difficulty, tends to absorb moisture to a limited degree, and has rather poor electrical properties. In molded form it has fair dimensional stability, but somewhat lower tensile strength than in filaments. It is still rather expensive.

Aside from its use as a textile material, the filament goes into bristles for brushes, surgical sutures, woven screens, cordage, etc. Molded or extruded nylon serves as gaskets, automobile wire insulation, nonbreakable tableware, slide fasteners, combs, and many others.

Polystyrenes

The polystyrenes include polymerized styrene and many copolymers of styrene compounds, along with some copolymers of styrene and butadiene. Butadiene is the basic compound in several of the synthetic rubbers. Some of these copolymers develop sufficient cross-linking to give them unusually high heat resistance for a thermoplastic material, and certain of them, with cross-linking carried farther, are true thermosetting resins. The entire family, though new, has shown great development and versatility, and there is good reason to believe that this will be one of the most important of the plastics families in the future.

At present it is difficult to present definite information about some of the types, for their composition has not yet been revealed. This is especially true of the new copolymers.

Styrene is made by reaction of benzene and ethyl chloride, to form ethylbenzene. It is also obtained as a by-product of several chemical processes. Synthetic styrene was one of the intermediate materials in the wartime synthetic rubber program, and for that reason was in good supply after the end of the war. Polymerization of the styrene must be carefully controlled.

Polystyrene is another of the few plastics suitable for making optical lenses. It is water clear and dimension-

ally stable, with excellent resistance to moisture. For the group, excellent electrical properties, especially at high frequencies, are a valuable characteristic. The polystyrenes and another series of compounds to be discussed later, the polyethylenes, are standard materials for high frequency and ultrahigh frequency insulation.

Color possibilities are practically unlimited, and may range from transparent to opaque. Injection molding cycles are rapid. Resistance to alkalies is excellent, but some strong acids attack the resin. Although it has good tensile strength, it is somewhat brittle.

In addition to polymerized styrene itself copolymers are available, and in these an attempt is made to eliminate some of the defects in polystyrene. One group of copolymers utilizes materials that will produce greater toughness, to overcome brittleness. Another group aims at higher service temperatures, to surmount the difficulty with most of the thermoplastics, a tendency to soften at temperatures approaching the boiling point of water. A third group produces thermosetting materials by introducing compounds into the styrene before polymerization to promote cross-linking.

In the first group of copolymers butadiene is a common added material. The resultant products are frequently rubbery types. The second group has several thermoplastics that will withstand temperatures above the boiling point of water without softening. The thermosetting types will withstand temperatures up to about 350 F without distortion or considerable loss of strength.

Polystyrene resins are also produced as liquid casting resins, using the unpolymerized styrene with a catalyst added. After forming in the mold, the resin can be polymerized at moderate temperature.

Polystyrene is available as a foamed material, as fibrous batts, and as an emulsion or solution, in addition to the molding materials and casting resins.

It is used for high frequency insulation, blown bottles, refrigerator parts, chemical containers, combs, battery boxes, dental plates, tableware, electroplating racks, etc.

Polyethylenes

The polyethylenes were developed during the war years in the United States after having been produced in England about ten years earlier. They are made by the high temperature, high pressure polymerization of ethylene, and a range of materials is obtained through varying degrees of polymerization. They are waxy-white solids, slightly flexible, and with excellent electrical properties. They are highly resistant to both alkalies and acids, and to most organic solvents also.

Polyethylenes do not soften until temperatures rise slightly above the boiling point of water, but an antioxidant must be incorporated in the material to prevent deterioration at elevated temperatures. Plasticizers are seldom used. Strength properties, brittleness at low temperatures, and other properties are varied by controlling the conditions of manufacture.

The resin can be molded by compression or injection methods, machined, blown, or extruded. It is used in coatings and lacquers, wire insulation, gaskets, washers, piping for the chemical industry, surgical sutures, acid-resistant clothing, etc.

Polytetrafluorethylene

This is the newest of the plastics, and is similar in many of its properties to the polyethylenes. Its outstanding attribute is its high-temperature resistance. Although a thermoplastic, the material does not soften appreciably until temperatures of about 700 F have been attained. It can be heated to plasticity, molded or formed, and cooled again.

A disadvantage is that the material begins to decompose at temperatures above about 300 to 400 F. The rate of decomposition is slow at these heats, but the gas liberated is a fluorine composition, and poisonous. It is recommended that the material be used in a draft of air when temperatures above 300 F are being used.

Caseins

The development and production of a plastics material for the proteinaceous substance casein, obtained from milk, was started in Germany about the beginning of the century. Production began in the United States about 20 years later. The material is difficult to classify, as it has some of the properties of the thermoplastic types combined with others characteristic of the thermosets.

Casein plastic is produced by the hardening action of formaldehyde upon casein. There is little opportunity for variation in operations, and the product cannot be produced in a variety of forms. By molding the casein under pressure and hardening with formaldehyde after the material has reached finished form, the scrap material can be reworked. After hardening, the casein plastic takes on the properties of a thermosetting resin, and cannot be softened by heat so as to reshape it.

This material is nonburning, has good resistance to organic solvents, and takes colors well. It is hygroscopic, and the swelling upon absorbing water and contracting upon drying causes the piece to deteriorate.

Typical uses include the manufacture of buttons, handles, buckles, small novelties, etc.

Silicones

A group of recently produced materials, the silicones, contains various rubbery materials made by polymerizing organo-silicon compounds. These are useful where elevated temperature resistance in the range 300 to 600 F is required. They are true plastics, in that they are organic in nature, are polymerized to high molecular weight, and are capable of being formed by flow. Some members of the group are rubbery, and might be thought of as high-temperature, synthetic rubbers. Others are molded thermosetting resins, and still others are varnishes for high temperature or electrical insulating use.

Approximate Physical Characteristics of Other Plastics

Type	Tensile Str., Psi.	Impact Str., Ft.-Lb. per In. of Notch	Specific Gravity	Top Service Temp., F	Water Absorption % in 24 Hr.
Acrylics	5,000-10,000	0.25-0.50	1.18	140	0.4
Polyamides	9,000-11,000	0.5	1.15	—	1.5
Polystyrenes	3,000- 9,000	0.25-0.50	1.06	165	0.05
Polyethylene	2,500	—	0.93	200	Very slight
Casein	10,000	1.0	1.37	300	10.

The silicones are synthesized from silicon tetrachloride and organic chlorides, and polymerized by condensation. Several types of compounds are possible, depending upon the organic chlorides used and the course of the reaction. These offer a range of properties valuable in industrial materials. Included in the products are:

Liquids, having (a) the property of nonwettability, and useful for waterproofing ceramics and glass; (b) relatively constant viscosity over a wide range of temperatures, and useful in aircraft instruments; (c) incompatibility with plastics and synthetic rubbers, and used as parting agents; (d) fluids for high-temperature baths; (e) special high-temperature lubricants.

Greases, for lubrication requiring chemical resistance or temperature resistance.

Rubbery materials, useful for electrical insulation at high temperatures, chemically resistant gaskets, or nonburning elastomeric applications.

Laminating compounds, used for preparation of fire-resistant panel board for aircraft, and similar uses. Glass fiber fabric is the usual filler.

One of the largest uses of silicones has been in the making of high-temperature insulation for motor windings. Use of a silicone varnish and glass fiber fabric to produce a nonburning insulation has made it possible to raise the working temperature of electric motors, and so to use smaller motors to produce a required output, or to get a larger output from a given motor. The greatest use has been in the aircraft industry, where weight savings pay large dividends.

Other materials are sometimes included with the plastics, some because they resemble the plastics as materials, others because they utilize plastics as an essential part of their product, and still others because they resemble the plastics in their fabrication or use. Natural and synthetic rubbers have already been mentioned. They are pure plastics within the definition agreed upon, but are usually thought of as a separate industry. Vulcanized fiber, a valuable industrial material made by chemical treatment of wood pulp, paper, or board, resembles plastics in some of its methods of fabrication and in uses, but lacks the concept of polymerization to high molecular weight as a part of its manufacture.

Resin-bonded plywood is sometimes included with the plastics because it makes use of resinous adhesives in its manufacture. From the viewpoint of the materials engineer it is a wood product. Shellac, one of the early natural resins used industrially, conforms with the requirement of moldability, but is not polymerized.

Another group, sometimes called the cold molded plastics, includes such materials as asphaltum and cement, made up with a filler. They embody the idea of plasticity, in that they are molded, but fail to conform with the true plastics otherwise.

Conclusion: Future Developments

There is no reason to think that possibilities for new plastics materials have been exhausted. Rather, the surface has been barely scratched.

Scientists are just beginning to understand the nature of the linkages that result from the particular kind of polymerization that produces plastics. It is known that straight chain or side-chain bonding produces plastics that are softenable by heat, *i.e.,* thermoplastic. When bonding takes place both as a straight-chain matter and between the chains, referred to as cross-bonding, the material loses this thermoplastic property, and becomes thermosetting. X-ray studies have verified this relationship between type of bonding and thermoplastic properties.

New plastics materials may be expected from the following developments:

(1) New plastics may be expected from some of the organic compounds upon which experiments have not as yet been tried. The use of the acrylic, vinyl, allyl, ethylene, and other organic radicals for polymerization into plastics seems to indicate that, under the proper conditions, a similar polymerization could be effected with many more of the organic groups. Furthermore, the fact that condensation of the allyl copolymers produces a thermosetting resin, while the corresponding reaction with the vinyls gives a thermoplastic material, offers a hint that interesting and valuable properties may be found in some of these future condensation products.

(2) New plastics may be produced from other esters and copolymers of presently used radicals, also. The first plastic, celluloid, was made from cellulose nitrate, and one of the newest plastics materials was the propionate of the same organic base. Many different combinations have been produced from vinyl bases, both by use of other esters and by copolymerizing several esters.

(3) The field of plastics blends or alloys, in which the finished plastics are intimately mixed together, holds enormous possibilities within itself alone. The compatibility of the various plastics and the mechanical problem of mixing them intimately are the only obstacles to the creation of an infinite variety of theoretical formulations, in which practically any combination of properties within the outside limits of the entire range of plastics could be obtained. Plastic blending has been started, and it will certainly produce a variety of new plastics materials as its techniques become better understood.

(4) Development of new formulations for present plastics, such as the use of new fillers, new plasticizers, new laminating materials, may provide plastics with new properties. The use of foaming agents to produce plastics of familiar composition but with very low specific gravity is an illustration of what may be done.

(5) New developments in fabricating techniques may widen the plastics horizons. Friction welding, for example, made possible the production of multi-colored buttons in which a plastic was faced with another plastic of different color. In other articles the plastic might be joined to a different type of plastic, or to another nonmetal, or to a metal. These new composite materials, and other materials that may be produced by future techniques, will be available to the engineer for solving his problems of material selection.

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CONTENTS NOTED

New Aluminum Solder

To the Editor:

Can you please supply me with a more complete address for Aluminum Solder Corp., which was mentioned in your article "Aluminum vs. Copper", appearing on page 61 of the February 1947 MATERIALS & METHODS?

The above is the request for information made in several letters received since publication of Mr. Knight's article. The complete address of Aluminum Solder Corp. is 10 E. 52nd St., New York. Another company with much the same product is Aluminium Co. of Ohio, 1360 W. Third St., Cleveland, Ohio.—The Editors.

Caustic Soda Quenching

To the Editor:

This letter has been occasioned by your well presented article in the January issue entitled "Caustic Soda as a Quenching Medium" in which was discussed the advantages and shortcomings of this material.

However, several of my fellow metallurgists as well as myself were irked in finding that this article was published as "An Outstanding 1946 Development in Heat Treating." A survey of the literature will show that in the early or middle twenties a paper was published . . . on the effects of quenching steel for hardening in different concentrations of caustic soda. Several companies as well as many of my fellow New England metallurgists have likewise been using this quench for years.

Your publication is, as it rightly should be, read in entity by the upper executive group of many of our leading manufacturing concerns. These may frequently have had little or no experience in the metallurgical end of the business. Some of my metallurgical contemporaries have been unduly embarrassed in trying to explain to their management that they have been using for more than a decade, a process that the "top brass" had been led to understand was an entirely new development of the past year.

I enjoy your publication very much and have on file all issues for over 10 years. Your digests of current literature have at many times been of considerable aid to me.

Lloyd E. Raymond

Stratford, Conn.

Our labelling of the article in question has been somewhat misunderstood, not only by some readers but also by the author. All are aware that quenching in caustic soda is not new. What we intended to convey was that this method is now much more widely applied on parts produced in tremendous quantities.—The Editors.

Westinghouse and the Metal Show

To the Editor:

Several of our people have called my attention to a statement on p. 5 of your January issue . . . "According to reports, Westinghouse arrived with their goods, encountered labor troubles, and went back home, etc."

Actually, this is an incorrect report, as all our people were informed several months before the convention that we had cancelled arrangements to participate. Therefore, no material was shipped for our booth. However, it was too late for the show management to sell the space, so there was a courtesy sign. As no Westinghouse goods were shipped, we naturally encountered no labor trouble.

Carl Nagel

Manager,
Technical Press Service,
Westinghouse Electric Corp.

Apparently we were gullible in this case and took an oft-repeated tale for the gospel truth. We are glad to have the facts in the matter and thus set to rest the rumor that reached us from the much maligned "usually reliable source."—The Editors.

NUMBER 137
April, 1947

METHODS . . . . . Process Control
MATERIALS . . . Heat and Corrosion Resistant Materials

Thermocouple Protecting Tubes

To insure longer life, with unimpaired accuracy, it is necessary to protect thermocouples adequately. Corrosion, contamination and abrasion all shorten the life of bare thermocouples. Protecting tubes are capable of withstanding these actions.

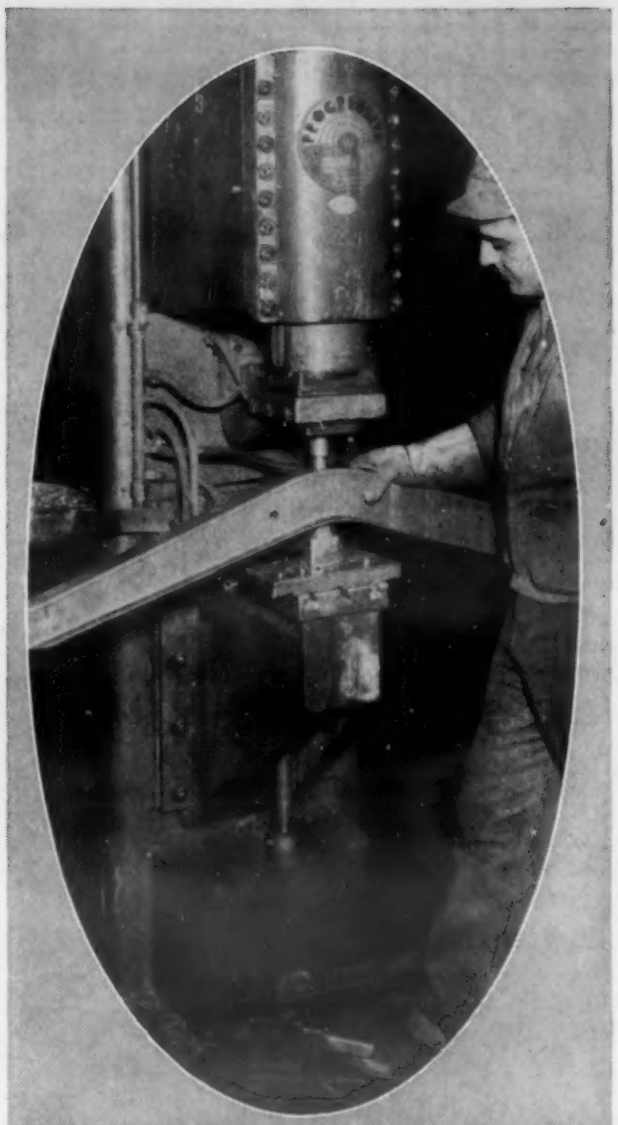
A thermocouple should have as little protection as possible, consistent with life characteristics. Sensitivity will be reduced and delayed response to temperature changes will result from use of very heavy tubes.

Recommendations for various atmospheres and media follow: For continuous duty the temperatures shown are the maximum recommended. For intermittent use tubes may be used at slightly higher temperatures than shown.

Type of Atmosphere	Maximum Temp. F	Material of Tube
Natural or Oxidizing (Ordinary Heat Treating)	2200 2400 2900	27% chromium iron Pure nickel or porcelain Porcelain
Neutral or Reducing (Carbon Monoxide) (Such as Gas Curtain Hardening)	2200 2400 2700	27% chromium iron Pure nickel or porcelain Porcelain
Hydrogen, Ammonia (Such as Bright Hardening or Brazing)	1000 2200 2700	Wrought iron or seamless steel 80 nickel-14 chromium-6% iron (Inconel) or pure nickel or porcelain Porcelain
Nitriding	2200	80 nickel-14 chromium-6% iron (Inconel) or 62 nickel-13% chromium
Slagging or Corrosive Action (Neutral or Oxidizing) (Such as Forging Furnace or Kilns)	2700	Fire clay with inner porcelain or P.B. Sillimanite
Slagging or Corrosive Action (Neutral or Reducing) (Such as Open Hearth Roof)	2500	Silicon carbide with inner porcelain
Sulfur Content	2000	27% chromium iron
Sulfur Dioxide	2200	80 nickel-14 chromium-6% iron (Inconel)
Hydrogen Sulfide	1000	80 nickel-14 chromium-6% iron (Inconel)
Lead Vapors (Rare Metal Refining)	2200	80 nickel-14 chromium-6% iron (Inconel)
Steam	1500	8 nickel-18% chromium
Steam	2000	80 nickel-14 chromium-6% iron (Inconel)
Carburizing	2000	27% chromium iron
Kind of Media		
Molten Sulfur	500	Monel
Cyanide or Salt Bath	1750	Drawn chromium iron (specially treated)
Salt Bath	2400	Same material as pot
Carburizing Salts	2000	Same material as pot
Dowtherm	—	Pure nickel or porcelain
Dilute Sulfuric Acid	180	Lead or Monel
Hydrochloric (Muriatic) Acid	20%-110 10%-140	Monel
Oil Baths	—	Seamless steel or wrought iron
Glass	2800	Porcelain
Tin	—	Extra heavy wrought iron or seamless steel
Lead	1000	Extra heavy wrought iron or seamless steel
Lead	2000	80 nickel-14 chromium-6% iron (Inconel)
Zinc (Galvanizing)	1000	Extra heavy wrought iron (put an open end pipe sleeve around the protection tube. This should be changed when eaten through.)
Brass (Intermittent Only)	2100	27% chromium iron
Brass or Copper Alloys (Intermittent Only)	2300	27% chromium iron
Aluminum	1500	Cast iron—paint with whiting daily
Magnesium (Dow Metal)	—	Extra heavy seamless steel or 27% chromium iron
Die Cast Metals	1200	Cast iron or extra heavy wrought iron—paint with whiting daily.

NOTE: In general, heavier tubes should be used for excessive corrosion or abrasion.

(Courtesy: Wheelco Instruments Co.)



How to Attach a threaded nut

The simplest and best way to attach a nut is to THREAD IT FIRST and then projection weld it to the part. That's what Midland Steel Products is doing on automobile and truck frames—using a Progressive Press Welder. NO RETAPPING is necessary after welding.

Formerly either arc-welded or mechanically attached to frames, these nuts (see sketch) are placed in a die on the lower platen of the welder. The part is slid along until a registering hole drops over the shoulder on the nut. The upper platen is brought down, one shot of current is passed through the nut, fusing the projections to the side-rail and the job is finished. A dozen or more nuts are attached to the side-rail shown in this manner. Nuts range in size from ¼ to ½ inch.

If you have a problem of attaching threaded studs or nuts to other parts, consult Progressive's PROCESS ENGINEERING DEPARTMENT. We will be glad to help you.

Are you reading Progressive's Resistance Welding Pictorial? Here you will find each month case histories of how WELDINGENUITY is cutting manufacturing costs and improving product appearance, performance and life. Ask for it on your company letterhead.

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RESISTANCE WELDING EQUIPMENT

MATERIALS & METHODS **Engineering File Facts**

NUMBER 138
April, 1947

MATERIALS . . . . . Aluminum Alloys
METHODS . . . . . Finishing

Coloring of Aluminum and Its Alloys

Aluminum has a naturally bright and attractive surface appearance. For a great many applications it is entirely suitable without the necessity for further finishing; many procedures and methods, however, have been worked out to satisfy our ingenuity and our love of variety.

It is possible to alter the reflectivity, appearance and color of bare aluminum through a variety of chemical and electrochemical methods. Since anodized aluminum may be dyed almost any conceivable color or tint through the proper application of the appropriate organic dye or inorganic salt, the methods involved are purposely omitted from the following tabulation of the various colored effects which may be produced on aluminum and its alloys.

Color Produced	Method Used and General Remarks
Frosted White	Immerse for a few seconds in hot sodium hydroxide, rinse in cold running water and then immerse in concentrated nitric acid at room temperature. Rinse and dry and coat with clear lacquer to prevent finger staining.
Bright White	Immerse for a few seconds in hot solution of sodium hydroxide and sodium fluoride, then proceed as in frosted finish. Resultant finish is brighter and more uniform.
Silver White	Boil for 10 to 15 min. in a water solution of silver nitrate, potassium chromate, potassium carbonate and sodium bicarbonate.
Oxidized Silver	Dip in solution of hydrochloric acid, arsenic, ferrous sulfate and copper sulfate. Repeated immersions result in oxidized silver effect.
Gray	(1) Anodize by any of the commercially practised methods. Chromic acid methods produce deep uniform gray colors; sulfuric methods may be used to produce hard clear to light gray coatings. (2) Boil for 5 to 10 min. in a water solution of potassium dichromate and sodium carbonate. (3) Boil for 30 min. in a water solution of potassium carbonate, sodium carbonate and potassium dichromate.
Iridescent	Immerse for 1 to 5 min. in a hot solution of ammonium hydroxide, ammonium chloride and suitable metal salts. Varying the metal salts alters the tint obtainable.

Color Produced	Method Used and General Remarks
Brown	(1) Immerse in cold solution of ammonium hydroxide and water. A velvety brown color is produced on aluminum-silicon alloys. (2) Immerse in boiling water solution of potassium permanganate, nitric acid and copper nitrate. Gray to brown to black coatings may result by changing the time of immersion.
Black	(1) Apply a carbonaceous material such as linseed oil, varnish, egg white, etc., and then heat until material is burned into the surface of the aluminum. Rather high temperatures are required (350 to 500 C), but the coating produced is a durable and adherent black. (2) Immerse in solution of platinum chloride and water or alcohol and then dry at 300 to 305 F. (3) Immerse in hot solution of water, boric acid, disodium phosphate and common salt. pH of the solution is maintained between 8 and 9. (4) Immerse for 60 sec. in water solution of ammonium molybdate, sodium acetate, and ammonium chloride.
Mottled Black	Immerse in solution of sodium fluosilicate, and sodium or potassium or ammonium nitrate, to which has been added copper or nickel salts. Interesting black and white effect is produced on irregularly shaped patches of aluminum.

Prepared by George Black

Short on Materials?

REMEMBER

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Here's welcome news to you many manufacturers who can't get your products on the market today for lack of raw materials:

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Monsanto Lustron offers in addition to ready availability: (1) rainbow range of colors (clear and opaque), (2) excellent electrical properties, (3) dimensional stability, (4) freedom from taste or odor, (5) low temperature strength, (6) excellent resistance to water, alkalies and acids, (7) light weight, (8) real economy.

Check your molder today . . . or write for full Lustron details: MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield 2, Mass. In Canada, Monsanto Ltd., Montreal; Toronto; Vancouver.

Does your production superintendent or your design engineer know there will be 80 million lbs. of Monsanto Lustron styrene in '47?

Lustron: Reg. U. S. Pat. Off.

MONSANTO
CHEMICALS ... PLASTICS

SERVING INDUSTRY . . . WHICH SERVES MANKIND

NUMBER 139
April, 1947

METHODS . . . . . Machining
MATERIALS . . . . Ferrous Metals

Thrust Loads in Drilling

Drill Size	CAST IRON					MACHINE STEEL				
	Feed in In. per Revolution									
	0.001	0.005	0.010	0.015	0.020	0.001	0.005	0.010	0.015	0.020
1/16	20	74	128	177	223	42	128	207	274	335
3/32	27	98	170	235	296	55	170	275	364	445
1/8	33	120	208	288	362	68	207	336	445	544
3/16	44	159	276	382	481	90	275	446	591	723
1/4	54	194	338	467	588	110	337	546	723	884
5/16	63	227	395	546	688	128	394	638	846	1035
3/8	71	258	449	621	781	146	447	725	961	1175
7/16	79	287	500	692	871	163	498	807	1070	1310
1/2	87	315	549	759	956	179	547	886	1175	1435
9/16	95	342	596	825	1040	194	594	962	1275	1560
5/8	102	369	642	888	1115	209	640	1035	1375	1680
11/16	109	394	686	949	1195	223	684	1105	1470	1795
3/4	116	419	729	1010	1270	237	727	1175	1560	1905
13/16	122	443	771	1065	1340	251	768	1245	1650	2015
7/8	129	467	812	1125	1415	264	809	1310	1740	2125
15/16	135	490	852	1180	1485	277	849	1375	1825	2230
1	141	512	892	1235	1550	290	889	1440	1910	2330
1-1/8	154	556	968	1340	1685	315	965	1565	2075	2535
1-1/4	165	599	1040	1440	1815	339	1040	1685	2230	2725
1-3/8	178	640	1115	1540	1940	362	1110	1800	2385	2915
1-1/2	188	680	1185	1640	2060	385	1180	1910	2535	3100
1-5/8	199	720	1255	1730	2180	407	1250	2020	2680	3275
1-3/4	209	758	1320	1825	2295	429	1315	2130	2825	3450
1-7/8	220	795	1385	1915	2410	450	1380	2235	2965	3620
2	230	832	1450	2005	2520	471	1445	2340	3100	3790
2-1/4	249	904	1575	2175	2740	511	1570	2540	3370	4115
2-1/2	268	973	1695	2340	2950	551	1690	2735	3625	4430
2-3/4	287	1040	1810	2505	3150	589	1805	2925	3875	4735
3	305	1105	1925	2660	3350	626	1915	3105	4120	5030
3-1/2	340	1230	2145	2965	3730	697	2135	3460	4590	5605
	CAST STEEL					CARBON STEEL				
1/16	29	96	161	219	271	50	146	233	306	371
3/32	38	127	214	291	360	66	195	310	406	492
1/8	47	156	262	356	440	81	238	379	497	602
3/16	62	207	348	472	585	108	316	503	660	800
1/4	76	253	425	578	715	132	387	615	807	978
5/16	88	296	497	675	836	154	452	719	943	1145
3/8	101	336	565	767	950	175	513	817	1070	1300
7/16	112	374	629	855	1060	195	572	910	1195	1445
1/2	123	411	691	938	1160	214	628	999	1310	1590
9/16	134	446	750	1020	1260	232	682	1085	1425	1725
5/8	144	480	808	1095	1360	250	734	1170	1530	1860
11/16	154	514	864	1170	1450	267	785	1250	1640	1985
3/4	163	546	918	1245	1545	284	834	1325	1740	2110
13/16	173	577	971	1320	1630	300	882	1405	1840	2230
7/8	182	608	1020	1390	1720	316	929	1475	1940	2350
15/16	191	698	1075	1455	1805	332	975	1550	2035	2470
1	200	668	1125	1525	1890	347	1020	1620	2130	2580
1-1/8	217	725	1220	1655	2050	377	1110	1760	2310	2805
1-1/4	233	780	1310	1780	2205	406	1190	1895	2490	3020
1-3/8	250	834	1400	1905	2360	434	1175	2030	2660	3225
1-1/2	265	887	1490	2025	2510	461	1355	2155	2830	3430
1-5/8	280	938	1575	2140	2650	487	1435	2280	2990	3625
1-3/4	295	988	1660	2255	2795	513	1510	2400	3150	3820

Note: Thrust loads are expressed in pounds.

Prepared by Canedy-Otto Mfg. Co., Chicago Heights, Ill.

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MATERIALS & METHODS

DIGEST

A selective condensation of articles—presenting new developments and ideas in materials and their processing—from foreign journals and domestic publications of specialized circulation.

Edited by H. R. CLAUSER

Mechanical Properties of Aluminum Bronzes at High Temperatures

Condensed from "Metallurgia"

Aluminum bronzes are pre-eminent among copper-base alloys in their resistance to oxidation and scaling at elevated temperatures.

Most 10% aluminum bronze is normalized to give alpha plus beta. This structure is retained indefinitely at ordinary temperatures but at moderately elevated temperatures, beta decomposes to alpha plus gamma$_2$. Gamma$_2$ is usually detrimental to room temperature toughness and ductility. Thus, a major problem was to ascertain if the unavoidable formation of gamma$_2$ was undesirable in elevated temperature service. Actually, a "stabilizing" treatment in which the beta was decomposed to alpha plus gamma$_2$ by a preliminary treatment at 930 F improved the creep resistance.

The tensile tests indicated no lack of strength and ductility at 750 F even in the stabilized samples where the gamma$_2$ reduced the room temperature elongation. In most cases, the strengths at 750 F were considerably higher in the stabilized condition than those of the corresponding normalized materials. Stabilization caused appreciable embrittlement up to about 840 F, at which temperature the notched bar values became the same for both types of heat treatment. At 1110 F, all the alloys, irrespective of their original condition, became tough because the alpha plus gamma$_2$ complex was reconverted to beta at temperatures above 1050 F.

The stabilizing treatment improved creep properties. Under these conditions, the stabilized is preferable to the normalized form in spite of inferior room temperature properties. If the relatively low creep resistance of the normalized material can be tolerated initially, no harm will be done by using it, because it will tend to improve during service due to the decomposition of the beta. In rupture tests at 480 F, the alloy containing 3% iron and 10% aluminum gave consistently longer life and greater extension at fracture than the same alloy without iron or an alloy with 10 aluminum, 5 iron and 5% nickel.

A comparison with tin bronze, gun metals and a copper-silicon-manganese alloy shows that tin bearing alloys are much inferior to the aluminum bronzes in their resistance to creep. While the silicon alloy appears to be slightly superior at 750 F, this material is handicapped by relatively large initial extensions. The aluminum bronzes appear to be the most promising of the copper-base alloys for service at moderately elevated temperatures. (E. Voce, *Metallurgia*, Vol. 35, Nov. 1946, pp. 3-9.)

Characteristics of Zircon Porcelain

Condensed from "Journal of the American Ceramic Society"

Zircon porcelain is a war-born product which is becoming of great permanent value. As the name implies, it contains a major portion, at least 50% by weight, of the mineral zircon.

This new porcelain is an extremely hard, dense, white mass somewhat heavier than the conventional types of porcelain. It lends itself well to the development of all types of vacuum or hermetic metal-to-porcelain seals. The stability of mechanical properties and shape at temperatures up to 1830 F or higher also merits consideration for special applications.

Zircon porcelain is exceptionally strong mechanically, and it has good electrical characteristics at normal and elevated temperatures, low electrical losses at high frequencies, and very good thermal-shock resistance. This excellent combination of properties affords zircon porcelain wide application in the low-frequency power field, in high-frequency and ultra-high frequency communications and signaling equipment, and in special installations where resistance to thermal shock or insulation of electrical circuits at elevated temperatures are prerequisites. No other known porcelain has such a diverse field of usefulness as zircon porcelain.

Among the current or impending electrical uses for zircon porcelain are components for radio, radar and miscellaneous high-frequency equipment; for example, sockets, tube bases, coil forms, terminal and switch plates, antenna insulators, and coxial cable terminals. Some of the other applications of zircon porcelain are capacitor dielectrics, spark-plug insulators, resistor tubes of all types, strain insulators, bus supports, bushings for transformer and capacitor cases, and large bushings and supports for application at elevated temperatures or over a wide range of frequencies. In addition to their electrical uses, zircon porcelains will undoubtedly find technical and mechanical applications where superior properties are required. (Ralston Russell, Jr. & W. C. Mohr. *J. Am. Ceramic Soc.*, Vol. 30, Jan. 1, 1947, pp. 32-35.)

Tungsten and Nickel Codeposition from an Aqueous Ammoniacal Citrate Bath

Condensed from "Metal Industry"

An investigation was made to determine the effect of bath pH on current efficiencies and on the percentage tungsten in the deposit. An aqueous ammoniacal citrate bath containing 10 gm. per l. nickel sulfate, 25 gm. per l. sodium tungstate and 66 gm. per l. citric acid with ammonia to give the desired pH at 160 F was used. The pH had much less effect on cathode current efficiency and on the tungsten content of the deposit than on the anode corrosion. The maximum tungsten was obtained with pH 7 and the maximum current efficiency with pH 7.4. The adjustment of the pH with sodium hydroxide instead of ammonia gave undesirably low cathode current efficiency.

In baths containing 10 to 40 gm. per l. nickel sulfate, 25 to 100 gm. per l. sodium tungstate and 66 gm. per l. citric acid, adjusted to pH 7 at 160 F with ammonia, it was found that the cathode current density had a great effect on the appearance of the cathode. In general, the cathode plates were streaked below about 6 amp. per sq. dm., bright in the medium range and somewhat

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fogged at high current densities. A definite improvement was noted when the pH was raised to 8, while triethanolamine gave further improvement and increased the bright range. However, triethanolamine could not be used as it deleteriously affected the bath stability.

An increase in the nickel sulfate concentration increased the current efficiency markedly, decreased the tungsten content of the deposit and promoted dullness of the plate. An increase in the citric acid content decreased the current efficiency and the tungsten content. An increase in current density increased the current efficiency significantly only with the higher citric acid concentration, but did not affect the tungsten content. The tungsten content of the plate increased with the bath temperature.

With 132 gm. per l. citric acid, an increase in the tungstate markedly decreased the current efficiency, but its effect was negligible with 66 gm. per l. citric acid. The tungsten content of the deposit was increased by an increase in the tungstate concentration. There was some cracking of the plate as the tungstate content was increased, but this was counteracted by an increase in the citric acid content.

Tests on the codeposition of other metals showed that only iron, cobalt, nickel and silver would codeposit with tungsten from this type of bath. (L. E. Vaaler & M. L. Hoyt. *Metal Industry,* Vol. 69, Nov. 22, 1946, pp. 434-436.)

Zicral—A New High Strength Light Alloy

Condensed from "Revue de l'Aluminium"

There are various reasons, both economic and scientific, why it takes so long to develop a new alloy. In France, only a single new high strength aluminum alloy has been introduced since duraluminum FR in 1935. This new alloy, A-Z8GU, required more than ten years laboratory work.

The strengthening effect of zinc had long been known, but the zinc-aluminum alloys had too little corrosion resistance for commercial use. Further research work was carried out in France, England, Germany, and America; all reached the same conclusions at about the same time. The intercrystalline corrosion of the zinc-aluminum alloys could be decreased by adding a small amount of other elements such as copper, chromium and vanadium, and by using an aging temperature above room temperature. The properties of the alloy were a function of the zinc and magnesium contents as well as of the ratio of these elements.

With this common background, each country developed its own formula for the new alloy. In France, where the utmost weight saving was necessary because of the scarcity of materials, an alloy with 2.5% magnesium and about 8% zinc was adopted. In England and America, a lower strength alloy with 2% magnesium and a little under 6% zinc was chosen because of its better fabricating properties.

The alloy Zicral of the A-Z8GU type has the following composition: 7 to 8.5 zinc, 1.75 to 3 magnesium, 1 to 2 copper, 0.1 to 0.4 chromium, 0.1 to 0.6 manganese, and 0.7% iron plus silicon. It can be rolled, drawn, and forged. Sheets are clad with a zinc-aluminum alloy to increase their corrosion resistance. It is a normally furnished solution treated by a quench in oil or water from 870 F and aged for eight hr. at 275 F or 24 hr. at 210 F. The properties of drawn bars are 78,200 to 92,500 psi. elastic limit, 85,300 to 99,600 psi. tensile strength, 6 to 10% elongation, 160 to 180 Brinell hardness, 22,800 to 25,600 psi. endurance limit, 99,600 psi. elastic limit in compression and 9,960,000 psi. modulus of elasticity. The density is 2.8. (Marcel Tournaire. *Revue de l'Aluminium,* Vol. 23, Oct. 1946, pp. 303-305.)

Clad Steels for Corrosion Resistance Applications

Condensed from "Corrosion"

The following factors affect the corrosion rate of metals: (1) nature and concentration of corrosive media; (2) temperature; (3) degree of aeration; (4) rate of flow or movement; (5) presence of impurities. The most reliable corrosion information is obtained from tests conducted in plant production equipment under conditions of actual service.

Proper selection of material is possibly the most important single factor in the design and fabrication of corrosion resistant equipment. There is no metal or alloy which is a "cure all" for all corrosion problems, each having its range of usefulness. In many cases, the most effective corrosion-resistant material is not the most economical material. Having available reliable corrosion rates, it is possible to select the most economical material, and design the equipment of clad steel for the required life or to obsolescence.

Good design of equipment made of clad steel is also important. It is desirable in weld joint design to eliminate fillet welds and lap joints where possible and also to eliminate all possible galvanic action from use of dissimilar metals. Continuity of corrosion-resistant surface is another important design factor.

Good fabrication of corrosion-resistant equipment is very important. With the exception of silver-clad steel, all clad materials are fabricated by practically the same procedure. In general, butt type welding with proper metallic arc electrodes is recommended. The corrosion resistant surface of clad steel plate should be protected from mechanical damage and iron contamination during fabrication.

Clad steels are very desirable for fabrication of large plant equipment which requires appreciable thickness of material for physical reasons. The following clad steels are commercially available in plate form: nickel, Monel, Inconel, stainless, straight chromium steels and silver. (Everett C. Gosnell. *Corrosion,* Vol. 2, Dec. 1946, pp. 287-306.)

Thick Nickel Deposits for Special Surface Protection

Condensed from "Mecanique"

Thick electrodeposits of nickel, like hard chromium deposits, are a magnificent industrial tool. These two metals are not competitive but complement each other; each has its own field of use.

Thick nickel deposits are among the most suitable means of building-up worn or mis-machined parts. Properly deposited, the nickel coating is homogeneous, adherent and machinable. It can be deposited on bronze, cast iron and all steels except those with high contents of tungsten or manganese where the adherence is mediocre. Satisfactory deposits can be made even on austenitic steels, high chromium steels and Monel metal. The hardness of the deposit may be varied from 150 to 450 Brinell by suitable modifications of the plating conditions. The most usual hardness range of commercial applications, however, is 200 to 230 Brinell.

These deposits are generally used for resurfacing contacting parts and for imparting resistance to wear and corrosion. Although the nickel does not have the wear resistance of hard chromium deposits, it work hardens rapidly to give a hardness of 280 to 290 Brinell. A large bearing surface, well dimensioned and lubricated, may be resurfaced with nickel if it is used at low or medium speeds.

The nickel plating of surfaces operating in contact with phosphorus bronze, lead bronze or nickel-cadmium alloys is not advisable. Heavily loaded bearing surfaces used at high speeds should be chromium plated if the amount of wear is less than 0.02 in. on the diameter. If the amount of wear is greater, they should be first nickel plated and then chromium plated.

It is impossible to indicate the cost of thick nickel deposits as each operation constitutes a particular case. (D. Chambaud. *Mecanique,* Vol. 30, Dec. 1946, pp. 285-289.)

Glass-To-Metal Joints

Condensed from "Sheet Metal Industries"

Joints formed by direct fusion of glass to metal may be divided into "matched" seals in which the expansions of glass and metal are very similar and "unmatched" seals in which the expansions differ substantially. Among the metals used are molybdenum, tungsten, platinum, 26% chro-

mium-iron alloy, 50% nickel-iron alloy (sometimes copper plated), 43% nickel-iron alloy and copper. In all cases, the surface of the metal must be clean. It is then oxidized very lightly before the glass is sealed to it.

Molten glass reacts with unoxidized metals to liberate gases which seriously weaken the seal. The oxide film prevents the glass from coming into direct contact with the metal and acts as a cement because all oxides are soluble in molten glass. The oxide layer must be thin, however, to prevent leaky seals.

In matched joints the expansion characteristics of the glass and metal must be such that the stresses resulting from differential contractions are not sufficient to cause the glass to crack. The best compromise is to seek a combination that will match in expansion near the upper annealing temperature and at room temperature. The expansions of glass and metal for matched seals must be carefully controlled to produce a prescribed stress in the glass dependent on the conditions the seal has to withstand in service. For general purposes, the glass in the joint should be in slight longitudinal compression.

In unmatched seals, the expansion of the metal substantially exceeds that of the glass so the glass is in compression and the metal in tension. If the metal is ductile and its cross-section sufficiently thin, satisfactory seals may be made in spite of expansion differences. Examples of this type are thin copper tubes sealed to W1 glass and molybdenum foil conductors sealed to fused silica.

The only unmatched seal which does not depend on the distortion of the metal is in the joining of tungsten or molybdenum to fused silica by means of a dome of a special glass. In this case the expansion of the glass is low enough to restrict the tension stresses at the glass-silica joint although the stresses at the metal-glass boundary are very high. (J. H. Partridge. *Sheet Metal Ind.*, Vol. 24, Jan. 1947, pp. 119-128.)

"Rubber Plated" Metal

Condensed from "Western Metals"

Rubber has excellent resistance to all chemicals except strong oxidizing agents, such as nitric and chromic acid, certain aromatic hydrocarbons, and the alephatic hydrocarbons. Since it has been found possible to vulcanize and to bond rubber to steel, its use as a corrosion resistant lining material has expanded rapidly.

The principal limitation of rubber is temperature. Under most circumstances rubber will withstand temperatures up to 180 F. Special compounds will handle certain materials at temperatures up to around 210 F, and possibly certain synthetics may be developed which will handle even higher temperatures.

Storage tanks of all shapes, sizes and varieties have been rubber lined. For numerous types of process tanks, rubber lining has become standard equipment. Use in plating tanks is another important application. Rubber, being a non-conductor, insulates the operation and prevents current leakage; it also prevents metallic contamination such as might occur with lead linings.

Rubber lined pickling tanks have proved to be quite satisfactory in service. Due to the severity of the service, the steel tanks are of rugged construction and ¼ in. of rubber lining with proper reinforcements are necessary. Inner linings of acid proof brick and cement are required to provide proper temperature gradient and protection against mechanical abuse.

Rubber linings can be installed in standard flanged fittings and in pipe sections up to 20-ft. lengths. Special headers, manifolds, bends, etc., lend themselves to the rubber lining process. There are three types of rubber lined valves in common use: the diaphragm valve, the ordinary gate valve, and a special design of angle valve. In piping work it is essential that the butt joints are even and that inner edges of flanges be ground to ⅛-in. medium radius. (W. S. Long. *Western Metals*, Vol. 4, Nov. 1946, pp. 16-19.)

Economies in Materials for Metal Parts

Condensed from "Métaux et Corrosion"

Savings in material may often be made by more precise design calculation or by a more intensive study of the properties of metals, testing methods and fabricating procedures. The relationships between the strength of finished parts and the various mechanical characteristics determined in the laboratory should be investigated.

Economies may also be realized by replacing a more expensive material by a less costly one or by the fabrication of parts with a minimum of machining. In material substitutions, however, it must be remembered that alloying elements in steel have some common attributes, but may have others which prevent their complete interchangeability.

Before the war, the highest hardenability steels were almost exclusively chromium-nickel or chromium-nickel-molybdenum with 3.75% nickel, 1.50% chromium and, sometimes, 0.40% molybdenum. Progressive shortages in Europe led to the use of chromium-molybdenum steels, then chromium-manganese and chromium-manganese-vanadium and, finally, manganese-vanadium, manganese-silicon and manganese steels. In general, these steels have lower hardenability than the older steels. In order to successfully use these substitutes, it was necessary to determine their properties, suitable heat treatments, and, particularly, the size ranges in which they could be used.

A good example of material economies resulting from substitution is the field of alloy steel castings. Formerly, chromium-nickel and chromium-nickel-molybdenum steels were generally used. Today in France, however, a large proportion are made of chromium-molybdenum steels with 1.5 to 3% chromium.

The fabricator has at least as much responsibility as the metallurgist in saving materials. The specification writer should not be influenced by the appearance of new test methods or by the more precise knowledge of the significance of mechanical characteristics to establish too severe acceptance requirements. Unnecessary requirements delay delivery, increase price and decrease the amount of acceptable material.

No laboratory test replaces service. When a practical service trial has shown parts to be satisfactory, a very simple test with the sole purpose of insuring the identity with previous shipments is adequate. This identity is a function of numerous variables and may be difficult to determine. One or more characteristics, judiciously chosen and statistically analyzed, should be capable of separating unusable products from those that are satisfactory. (G. Delbart. *Métaux et Corrosion*, Vol. 22, May 1946, pp. 64-65, 72.)

Plating With Gold

Condensed from "Metal Finishing"

The ability of gold to resist corrosion and tarnish oxidation at high temperatures and its almost complete imperviousness to chemical attack, ideally suit it for laboratory apparatus, electrical contacts and cavity resonators in radio, pen points, and infrared lamp reflectors. Its use in tableware, musical instruments and jewelry is also widespread.

Two objections to the use of pure gold are its softness and its prohibitive cost. But both these objections can be overcome by coating a harder and cheaper metal with a thin film of gold by means of plating. A coating as thin as one-millionth of an in. or less may be applied and still give the finished work the desired durability and beauty.

There are four methods of plating gold. The oldest process is known as mercurial gilding. It is the most uneconomical of the four. However, the important advantage of the method is that both the thickness of film and its color can be controlled.

The immersion method involves nothing more than immersion of the work in a suitable bath, without use of electrodes or external current, and allowing it to remain until gold transfers from the solution to the work piece. Only a thin coating of gold is possible with this method, but the film is of high specific gravity and therefore of good quality. The method has the advantage of simplicity and resultant low cost.

The single cell or salt water method, like the immersion method, requires no external source of electricity. It uses a zinc

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electrode suspended in a salt solution. The salt solution is contained in a porous pot which, in turn, is set in the gold solution. A copper wire connects the zinc electrode and the work hanging in the gold solution. The coating obtained is very uniform in thickness and color and will stand up adequately under moderate service.

Electrogilding is the most common method. Here a gold anode (or sometimes platinum, stainless steel, nichrome, or hard carbon) is used in the gold solution and external source of current applied. This method permits the maximum amount of control both as to thickness and color. For quantity production this is the preferable method. (H. M. Haberman. *Metal Finishing*, Vol. 44, Dec. 1946, pp. 525-528.)

High Temperature Properties of Magnesium-Cerium-Zirconium Alloys

Condensed from "The Journal of the Institute of Metals"

Sand cast binary magnesium-cerium alloys with about 3% cerium have good strength and resistance to creep at 390 F. They are not hot-short or susceptible to serious shrinkage troubles, and cast well in sand molds. However, their mechanical properties at room temperature are poor and are apparently incapable of improvement either by superheating before pouring or by heat treatment.

By the addition of zirconium, alloys are obtained which have room temperature properties comparable to those of the usual casting alloys. For example, sand cast test bars of an alloy with 2.57% cerium and 0.49% zirconium had a 0.1% proof stress of 13,775 psi., an ultimate stress of 23,520 psi., and an elongation of 5.8%.

A series of sand cast test bars with the same nominal zirconium content (0.6%) but with 0 to 5.5% cerium showed that cerium within this range has no marked effect on the ultimate stress although the proof stress increases steadily with the cerium and reaches 17,695 psi. with 5.5% cerium. The Brinell hardness also increases with the cerium content, but the elongation decreases sharply with the addition of small amounts of cerium and is further reduced as the cerium is increased. The best combination of properties at room temperature is possessed by magnesium-cerium-zirconium alloys with 2.5 to 3.5% cerium. Little gain in properties results from heat treatment of these alloys.

The resistance to creep of the magnesium-cerium-zirconium alloys is far higher than that of the usual magnesium casting alloys. The creep resistance at 390 F of certain of these alloys is very little inferior to that of the widely used aluminum alloys of the R.R. 50 (DTD 133 c) type. The combination of good casting qualities and good mechanical properties at ordinary and elevated temperatures makes the magnesium-cerium-zirconium alloys attractive for some important light-weight stressed components of engines for which magnesium base materials have hitherto been unsuitable.

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The addition of certain other elements such as calcium, zinc and silver, does not affect the good high temperature properties of the magnesium-cerium alloys. The room temperature mechanical properties of the magnesium-zinc-cerium-zirconium alloys tested are, however, inferior to those of the magnesium-cerium-zirconium alloy with the same cerium content. (A. J. Murphy & R. J. M. Payne. *J. Inst. Metals*, Vol. 13 Nov. 1946, pp. 105-128.)

Materials and Methods for Aircraft Construction in France

Condensed from "Revue de l'Aluminium"

During the war Zicral or T.60, an aluminum alloy with zinc, magnesium and copper as the alloying elements was developed in France. This alloy has about 79,600 psi. tensile strength, 67,000 psi. elastic limit, and 8% elongation. Its application is still not general in the airplanes currently being produced but most of the prototypes have been substantially lightened by its use. Of accessory alloys for airplane use, the 3 to 5% magnesium alloy of the Duralinox type might be cited, as well as the new duraluminum alloy with 1.5 to 2% lead created because of the brass shortage.

Continuous casting and continuous rolling in four high rolling mills are not new, but their industrial exploitation is quite recent. Numerous forming methods known prior to the war have been improved: forming in hydraulic or mechanical presses with steel or cast iron punches and dies; forming with zinc alloy dies (Kirksite); stamping with rubber pads and Masonite dies in hydraulic presses.

Riveting has been only partially supplanted by welding. Automatic riveting machines have not been used as widely as they might. Developments have been confined mainly to rivets for assemblies accessible from one side only, high shear strength rivets (usually of hard steel and sometimes even of stainless steel) and dimpling of very high strength alloys where heating is usually required.

Welding, however, is growing in importance. The control of surface preparation by measurements of the contact resistance and of the operation of welding machines have been improved while harder electrodes are available. Atomic hydrogen welding, argon or helium welding, the Weibel process and weld-brazing with a 5% silicon-aluminum alloy, are processes receiving

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reased attention in the aircraft pro-tion field.

In machining, most of the machines in ation factories lack the speed and power using new tools to the best advantage. ogress has been made in the field of lls, milling cutters, turning tools and nd saws. The use of synthetic glues for ning light metals, either to each other to plastics and wood, may have a great ure.

Little change has been made in casting oys except for the introduction of the % magnesium alloy. Normal duralum-um and duraluminum FR are currently ed for forging, although recent tests on ry high strength alloys of the Zicral type e promising. (J. Guillemin. *Revue de Aluminium*, Vol. 23, Nov. 1946, pp. 339-54.)

An Abrasion Tester to Determine Wear Resistance of Materials

Condensed from "The ASTM Bulletin"

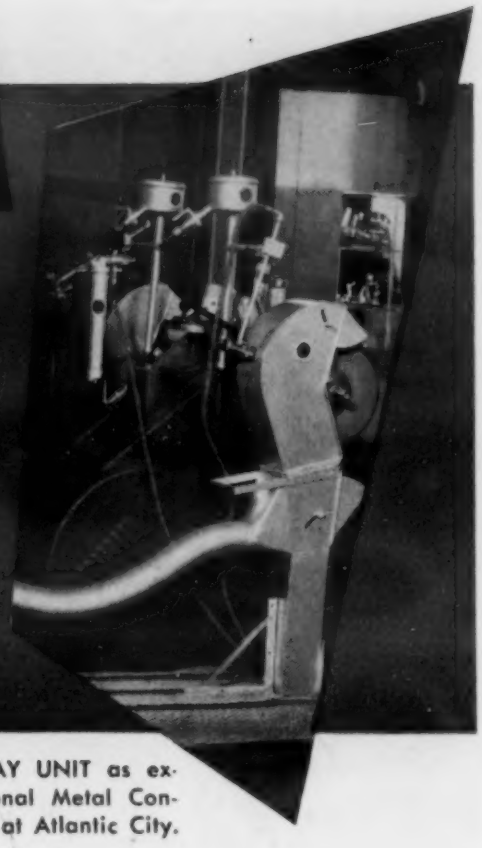
The technique of obtaining a quantitative measure of the resistance of a material to the effects of routine wear has always been a problem. An abrasion machine employing a continuously changing abrasive surface has been developed to test for wear materials such as painted surfaces, metals and synthetic resins.

Essentially, the machine consists of two independent units: (1) a vertical track which carries the specially prepared specimens around to meet the abrasive, and (2) a carriage which rests on roller bearings and has provision for keeping a strip of sandpaper in continuous motion while abrading the samples. The directions of motion of the sandpaper and samples are opposite, and contact between the two is maintained by dead weights attached to the carriage by a cable-spring-pulley arrangement.

Standard comparison specimens of zinc are tested with each run. Measurements taken on these standards over a period of years have shown the sandpaper to be reasonably consistent.

The instrument described is an abrader which measures simply the abrasion resistance of various materials under standardized conditions and is only for comparing the sandpaper abrasion resistance of various materials—not for comparing the relative suitability of these products for any general service. (F. M. Gavan, S. W. Eby, Jr. & C. C. Schrader. *ASTM Bulletin*, No. 143, Dec. 1946, pp. 23-29.)

ANNOUNCING THE LEA NON-FLAMMABLE Emulsion Spray METHOD OF POLISHING AND BUFFING



LEA EMULSION SPRAY UNIT as exhibited at the National Metal Congress and Exposition at Atlantic City.

EFFICIENT . . .
No time lost for heading up wheels; operator at all times can use both hands in handling the work being finished.

FLEXIBLE . . .
Operations can be entirely automatic, that is, with continuous spraying or timer controlled intermittent spraying; or spraying can be controlled by foot treadle.

MAINTENANCE . . .
All parts used are of well-known standard manufacture and designed to give long service. The entire apparatus, when using Lea Emulsion Spray Composition, can be cleaned with hot water without dismantling.

SAFE . . .
It's completely non-flammable.

CLEAN . . .
Excess amounts of spray never present; work is clean.

ECONOMICAL . . .
Spray composition requirements 50% of bar composition or even less; no wastage in butt end or nubbins. Special valve design permits close control of composition in the spray. It saves on buffs, too, because of the uniform coating.

The Lea Emulsion Spray Method of Polishing and Buffing is so widely adaptable that we suggest you look into its usefulness in your shop. Tell us what your work schedule is and we'll be glad to recommend the proper size Lea Spray Machine.

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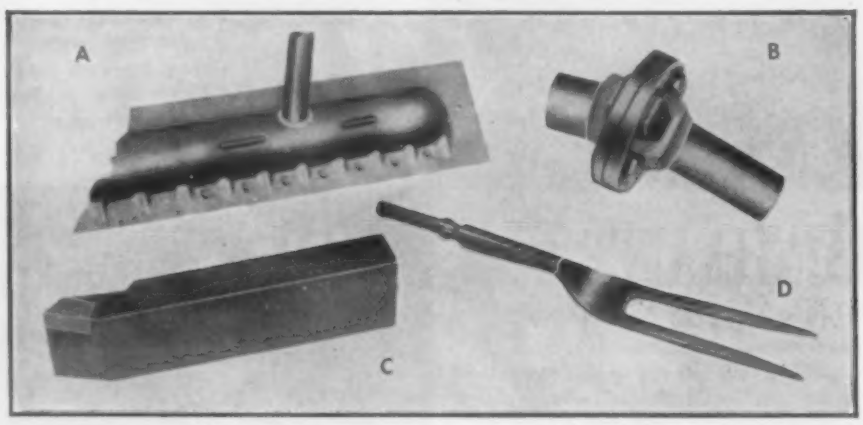

A-Stainless Steel & Copper Refrigerator Sub-Assembly. B-Brazed Steel Universal joint. C-Carbide Tool Tip brazed to Shank. D-Stainless Steel Fork Assembly.

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PRECIOUS METALS SINCE 1875

BOOK REVIEWS

How Modern Steel is Made and Used

THE METALLURGY OF QUALITY STEELS. *By C. M. Parker. Published by Reinhold Publishing Corp., New York, 1946. Cloth, 6¼ x 9¼ in., 248 pages. Price $6.00.* The author of this book is well-known in the American steel industry—he is secretary of the General Technical Committee of the American Iron & Steel Institute. The material is based on wartime educational lectures. The discussions follow fundamentals pretty closely, though some of these are controversial, with the author leaning to the conservative side.

The text is well written, the subjects thoughtfully chosen, and there are over 160 illustrations. The 13 chapters cover a wide variety of subjects. The scope of the work is indicated by a list of the chapters: I—The General Nature of Steel; II—Steel Quality as Related to Method of Manufacture; III—Steel Quality as Related to Ingot Practice, Chemical Composition and Control; IV—Steel Quality as Related to Rolling Practice; V—Inspection Procedures Used to Determine Steel Quality; VI—The Mechanical Testing of Steel; VII—Thermal Critical Points and Solid Solution Changes; VIII—Annealing, Normalizing and Spheroidizing; IX—The Effects of Alloying and Incidental Elements; X—The Hardening of Steel; XI—Hardenability; XII—Special Characteristics of Steel; and XIII—General Characteristics of Standard Steel Grades.

A Russian Book on Corrosion

THEORY AND RESEARCH METHODS OF METALLIC CORROSION. *By G. W. Akimow. Published by Academy of Science of U.S.S.R., Moscow, 1945. Cloth, 6¾ x 10½ in., 414 pages. Price 34 rubles. (In Russian.) Obtainable from Mzdumarodnija Kniga, Kusnetski most 18, Moscow, U.S.S.R.* This is a very comprehensive work divided in two parts, as its title indicates. The first part, dealing with the theoretical aspects of the corrosion of metals, is a well assembled summary of the theory of corrosion. One must compliment Professor Akimow on the excellent arrangement of the material and rather concise presentation. In a sense this work is an excellent supplement to the book by Evans.

This reviewer noticed one omission which should be mentioned. Little—in

…t, practically nothing—is said of the …mbined erosion and corrosion action. …his topic is of quite considerable im…rtance, and it should have been dis…ssed in light of the progress of studies …de in recent years.

The second part, dealing with the …ethods of investigation and factual data … results of corrosion studies, suffers …mewhat from the lack of up-to-date in…rmation. The study of references indi…tes that the author has not had access … the publications in this country much …yond the year 1938 or, at the latest, …940. It is probably for this reason that …ndue emphasis, it seems to this reviewer, …s been placed on the importance of salt …pray or some, now obsolete, methods of …udying intercrystalline corrosion.

On the other hand, the reviewer was …rticularly impressed with, for example, … careful and interesting table which sum…arizes various methods of studying cor…osion and estimates their practical and …eoretical usefulness.

The book is an obvious and pleasant …provement, insofar as its appearance is …ncerned, upon former publications of …e U.S.S.R. It should be translated into …nglish, and let us hope that it will be. …When translated, it will be a very worthy …ntribution to the subject of corrosion.

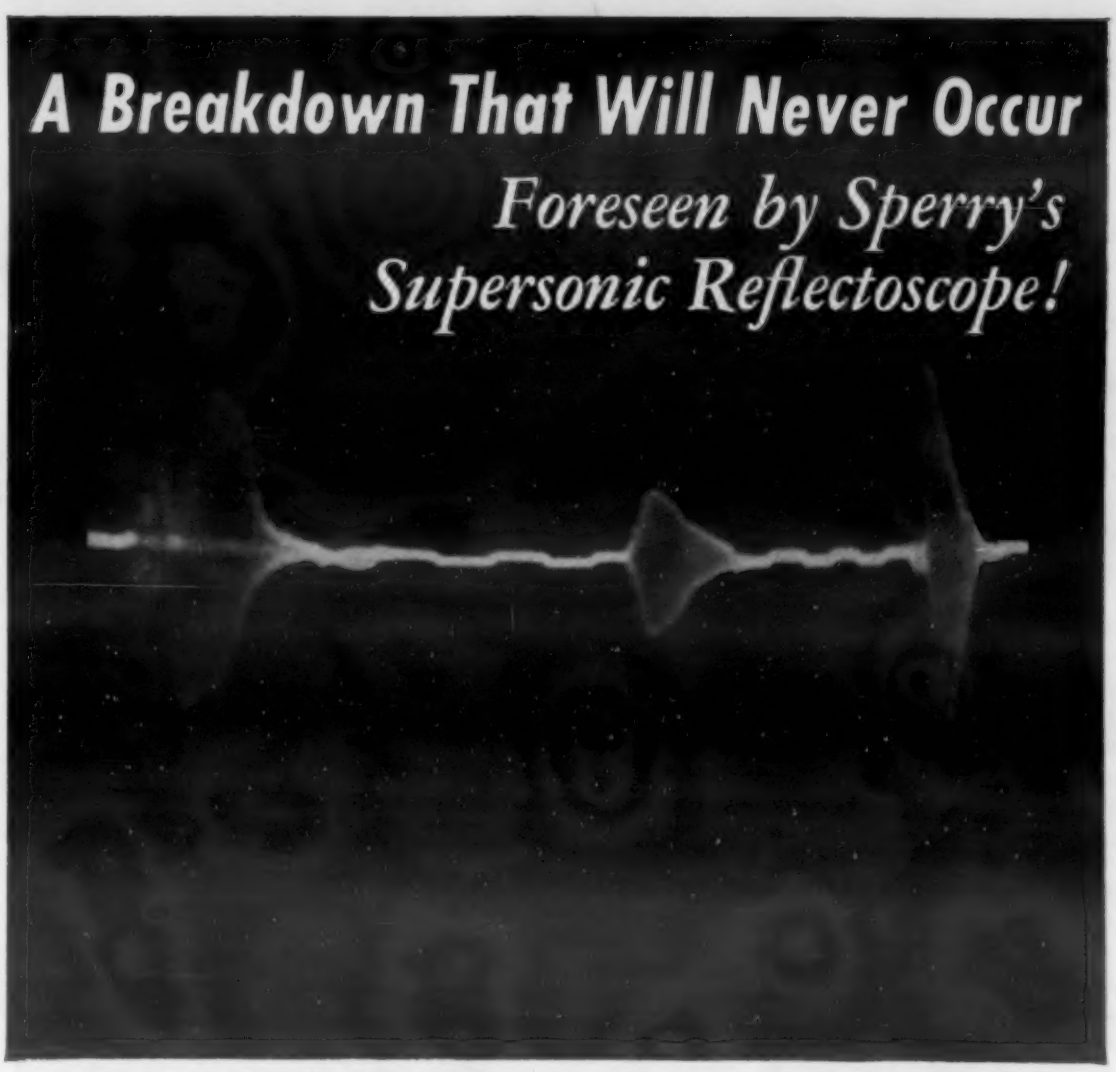
In passing, the reviewer would like to …ention that he was interested in the …doption of some English words into the …Russian language. One of such is "pit…ing," another, "intercrystalline." This cir…umstance should perhaps give us a ray …f hope that some time the scientists of …he world will speak the same language.

—V. N. KRIVOBOK

Other New Books

A.S.T.M. METHODS OF CHEMICAL ANALYSIS OF METALS. *Published by American Society for Testing Materials, Philadelphia, Pa., 1946. Cloth, 9¼ x 9½ in., 402 pages. Price $4.50; to A.S.T.M. members (extra copies), $3.00.* This volume has been greatly expanded over the last previous one, that of 1943. It gives in their latest form the 35 extensive standards developed by A.S.T.M. committees. The new book has 402 pages, compared with the 330 pages in the 1943 volume. It includes not only modernized versions of some older methods, but also several newer photometric and spectrochemical methods of analysis for certain materials and elements. Of the 35 standard methods, seven cover photometric and 5 spectrochemical procedures. Of the 35 methods, 16 carry 1946 designations, indicating they were either new this year or have been revised.

HEAT TREATING ALUMINUM ALLOYS. *By O. L. Mitchell and G. W. Birdsall. Published by Technical Editorial Service, Reynolds Metals Co., Louisville 1, Ky., 1946. Paper 6 x 9 in., 144 pages. Price $1.00.* Designed to furnish information to both the non-technical and technical man, this book provides a handy reference source for users of aluminum alloys. Starting with a discussion of the metallurgy of the heat treatment of aluminum alloys, the authors then cover heat treating cycles and, finally go into detailed technical discussions of annealing, solution heat treating, aging and heat treating equipment, concluding with a glossary and tables of mechanical properties of various types of aluminum alloys—wrought, sand casting, permanent mold casting and die casting.



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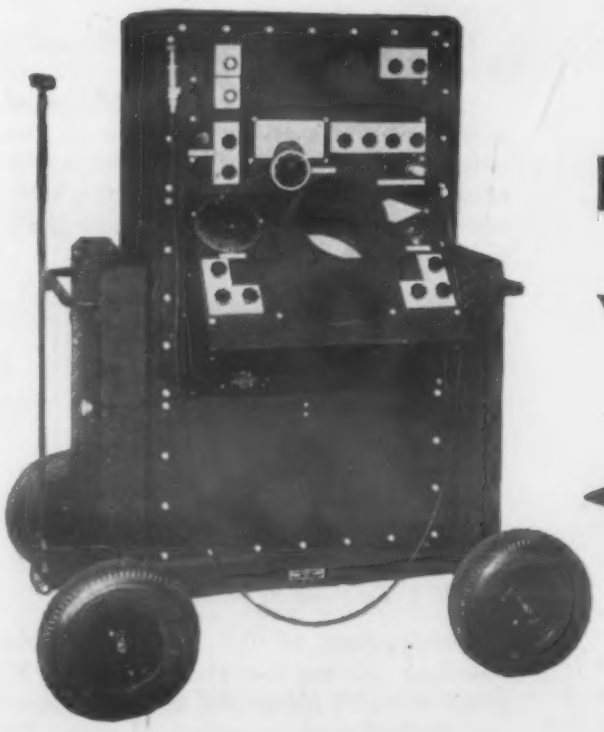

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Engineering Shop Notes

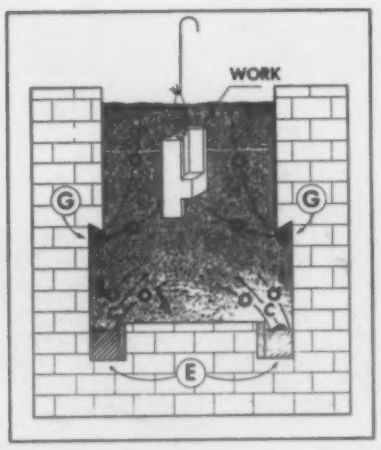
Electric Salt Bath Furnace Electrodes Renewed Automatically

by E. F. Elliott,
Upton Electric Furnace Div.

A new means of automatically renewing electrodes which have been permanently sealed in among the refractory matter at the bottom of an electric salt bath furnace has been developed. The method makes use of graphite rods and the natural chemistry of a high temperature salt bath furnace to cause the electrodes, which are normally wasted away during high temperature heat treating, to renew or "self-perpetuate" themselves. Source of the renewing agent is the presence of oxides which are normal to any high temperature salt bath.

The electrodes—there are usually two in the average high heat furnace—are located in a slot or pocket in the bottom of the furnace. On each side of the pot and immediately above each electrode there is a ledge or overhang of refractory material that is slightly wider than a graphite rod. The graphite rod, being of considerably lower specific gravity than the salt, is thus held against the under side of the ledge by its buoyancy once it is placed in position.

As the oxides contact the graphite rod, they are reduced to a metallic state, and since their melting point is higher than that of the bath, they form a metallic scale on the graphite rod.



Sketch indicates how oxides which form in the bath are employed to self-perpetuate the electrodes.

However, the contact with the carbon rod increases the carbon content of this metallic scale and reduces its melting point until the scale melts and drops from the rod. Since the rod is immediately above the electrode, the metal falls on the electrode.

Here, out of contact with the carbon of the rod, the oxides in the bath will reduce its carbon content until it becomes a solid, integral part of the electrode itself. This process continues automatically until the carbon rod has been consumed, when a new rod can be inserted under the ledge.

In some heat treating operations this automatic renewal of the electrodes may not be fast enough because of the type of work being treated or because the graphite rod can not be used. In these instances an "auxiliary" and very rapid means of replenishing the electrodes exists. This consists of simply dropping some cast iron into the bath. Since the cast iron is of lower temperature than the bath, it will melt and run over into the slot. Then, by the simple chemical action outlined above, the oxides reduce its carbon contents so that it becomes an integral part of the electrode.

Thus, by either means, the electrodes never need changing and they will, in fact, out-last the furnace itself. Additional advantages claimed for the use of the graphite rod are that it reduces the tendency for decarburization of the work being treated, and also keeps the bath quiet and completely neutral.

Metal Cleaning with the Sodium Hydride Process

by H. L. Alexander,
E. I. du Pont de Nemours & Co.

Development of the sodium hydride descaling process has made available to metal working shops and plants a cleaning method with a variety of uses. To produce the desired cleaning and descaling action, the process utilizes the reducing action of small quantities of sodium hydride, which are dissolved in a fused caustic carrier bath operated at 700 F. A water quench and rinse follow. These either complete the cycle or prepare the work for subsequent operations.

When perfectly clean surfaces are desired, the cycle is completed by a short acid dip and a water rinse. The acid dip may be eliminated in many cases when preparing surfaces for hot dip lead or zinc coating, enameling, or machining.

An application of the sodium hydride descaling process has been developed recently by a manufacturer who uses a proprietary paint as stop-off for the selective carburizing of various steel parts. By the use of this stop-off paint, the manufacturer can effect considerable saving; however, after heat treatment, the scale resulting from the paint is extremely difficult to remove by normal methods, containing, as it does, a considerable amount of finely divided silicious and cuprous material. Treatment in the sodium hydride bath completely reduces the scale present and removes all traces of the silicious material. A treatment of approximately 10 min. in the sodium hydride descaling bath with subsequent water quench produces parts suitable for further machining operations.

The use of the sodium hydride treatment for descaling prior to plating is arousing considerable interest. In many cases it is possible to either eliminate acid completely or to confine its use to a short final dip prior to actual plating operations. The process is particularly effective in descaling small, intricately shaped parts which are normally cleaned in batches.

Improved electroplated coatings of copper and nickel have been obtained when small, heat treated parts were descaled and then plated. While batch anodic cleaning previously produced only fair plating results on the inner surfaces, much-improved plating is being obtained now that a newly installed hydride descaling unit is in use.

Another recently developed use for sodium hydride is in desanding and descaling intricate castings, such as pump and compressor parts, which must be thoroughly cleaned before final assembly.

The hydride treatment is used following normal sand- or shot-blasting operations; it should not be used, however, as a means of primary sand removal. This desanding application is also used prior to such machining operations as broaching and other work for which expensive tools are used and in which imbedded sand is extremely injurious to tool life.

Planning Heat-Treat Cycles to Avoid Production Delays

by J. Edwin Burkhardt, Glenn L. Martin Co.

The problem of eliminating production delays caused by the necessity of heat treating various aluminum alloys for different time periods practically has been solved at the Glenn L. Martin Co., through the adoption of a revised time cycle for heat treatment. This cycle was found satisfactory for at least four different alloys —53S, Alclad 14S, R-301 and 61S.

Under the old method, the four alloys were aged at two different time periods; 14S and R-301 were aged together at 350 F for 6 hr., while 53S and 61S were aged together at 350 F for 8 hr. This resulted in delay on rush jobs due to the difference in the time, and the necessity either to hold 14S and R-301 for 6 hr. while the furnace was being used to age 53S and 61S for 8 hr., or using the engine mount furnace, rivet furnace or wood shop furnace for heat treating some of these alloys.

Under the revised method, the four alloys are all aged together at 350 F for 8 hr. or 340 F for 10 hr. This saves at least 40 hr. of furnace time each week, and eliminates the need for using other furnaces, thus at the same time eliminating delays in the heat-treat of rivets and motor mounts. There is also a small direct saving of additional loading and unloading, and transportation of aluminum alloys to different furnaces. Storage space is also saved, as it is not necessary to rack up an accumulation of aluminum waiting to be heat-treated. The shop benefits through more efficient planning without the usual heat-treat delay when working the materials that have the same heat-treat specifications.

Either of the time cycles has distinct advantages over the old method. The 8-hr. treatment at 350 F permits the aging of at least four different alloys in the same furnace load. The 10-hr. treatment at 340 F permits the shop to age this material during the interval between second and first shift; the second shift can put it in the furnace, the heat can be run while no one is working, and the day shift can take it out. Either time cycle eliminates the tie-up of other department furnaces and delay in rush jobs. The aging cycles conform with government specifications.

A Handy Milling Fixture

by Robert Mawson

A small machine shop recently devised a useful milling fixture to simplify the machining of a large quantity of small brass connectors. In the illustration the part is shown as it comes from the screw machine, which is the first operation, and also a view of the finished piece. In this latter view it will be seen that the piece has two sides milled to ¼-in. wide and for a depth of 5/16 in.

The rather interesting fixture designed for this milling operation is made with a machine steel base "A," which is fastened with screws through the four holes shown to the cross-slide of a small lathe. On this base is fastened a fixed jaw block "B" and a jaw "C" of somewhat similar design. The jaw "C" oscillates on pin "D." At the upper end of the jaw blocks is a flat leaf spring "E."

On the outer face of the jaw "C" a cam lever "F" moves around pin "G." At the outer end of the rod, which is screwed into the cam lever, a machine eye is attached. To this eye is fastened a steel cord that passes over a drum, fastened on the face of the lathe bed, and then continues downward to a foot operated pedal.

The hole "H" in the two jaws is machined slightly smaller than the shank of the piece being milled so that when the jaws are closed the piece will be held firmly in position.

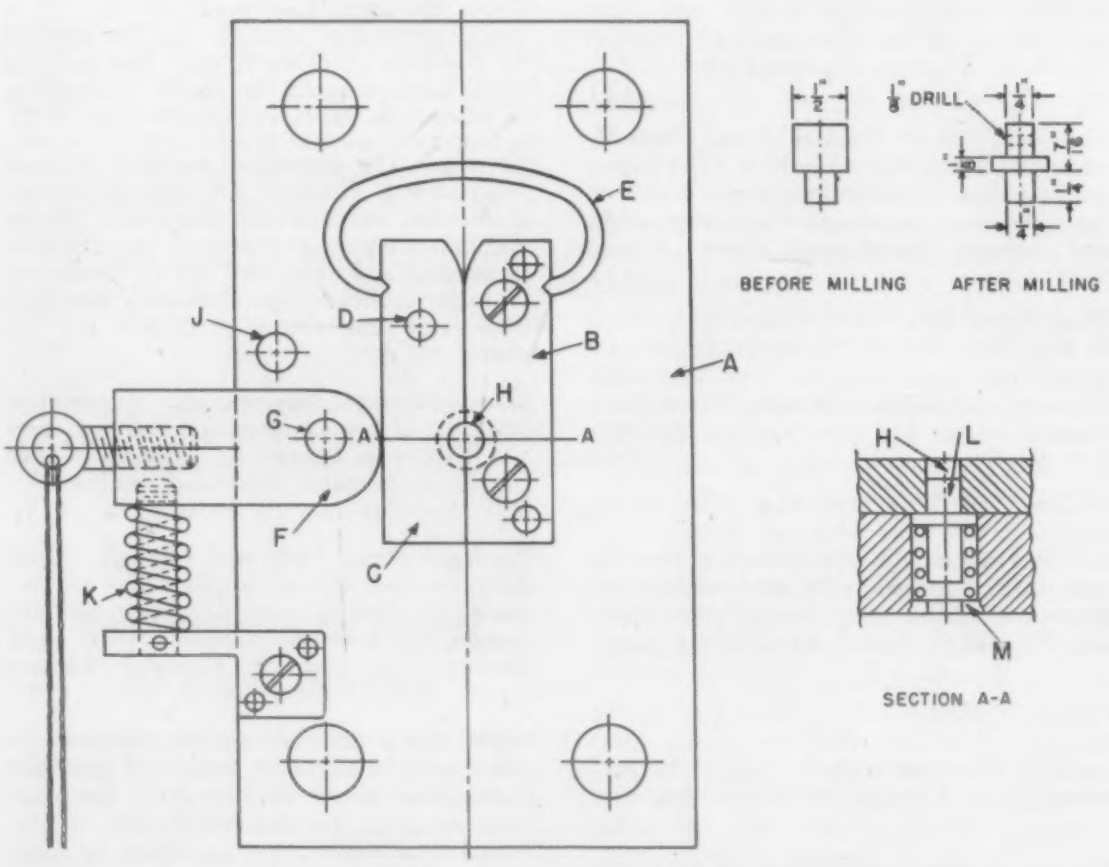
To use the fixture, the operator removes his foot from the foot pedal and spring "K" forces the cam lever back against stop pin "J." With the cam removed from block jaw "C," the jaw can slide out swinging on pin "D" by reason of the tension exerted with spring "E." It will be noticed that the upper inner surfaces of the jaw blocks have been relieved so that block "C" can swing out without interfering with the fixed jaw block.

The operator then places the piece to be milled in hole "H," pushing the piece down until its shoulder is in contact with the upper surfaces of the blocks. The operator then pushes down the foot pedal and this motion forces the loose jaw block against the fixed jaw, thus holding the piece in position.

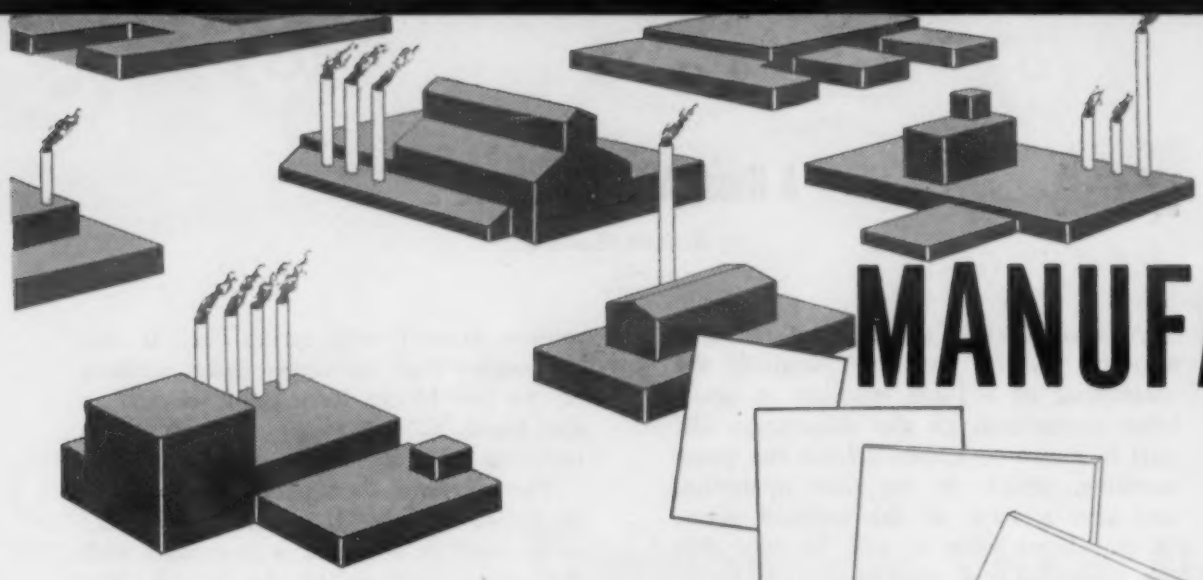
Since the fixture is attached to the cross slide of the lathe, when the cross slide is fed under the two side milling cutters, which have been correctly spaced, the sides of the piece are milled to the proper width. The cutters and spacer are held on an arbor in the lathe and driven by a lathe dog on the arbor in the usual machining manner.

Referring to the sectional view, it will be noticed that a pin "L" has to be pushed down about ⅛ in. in order to bring the shoulder of the piece to be milled onto the jaw surface. Therefore, when the operator releases the pressure on the foot pedal and the jaws open, spring "M" pushes up pin "L" against the end of the piece, which has been milled, and forces it out of the fixture jaw blocks.

So, with this device it is only necessary to load the piece in the fixture for the milling operation. Unloading of the finished piece is performed automatically; as a result, the machining cycle and manufacturing cost is reduced materially.



The drawing shows the principal parts of the fixture and the shape of the part being milled.



MANUFACTURERS'

Materials

Cutting Tool Materials. A comparison of the basic characteristics, properties and uses of high-speed steel, cast alloys, and carbides as cutting tools is presented in a 32-page, illustrated bulletin offered by Allegheny-Ludlum Steel Corp. (1)

Stainless Steel Fasteners, Etc. Detailed tabulations of stock sizes, specifications, corrosion resistance, etc., of a complete line of stainless steel fastening devices and other parts are offered by Allmetal Screw Products Co. in an 84-page, illustrated catalog, No. 44. (2)

Aluminum Bronze Machine Tools. This 4-page, illustrated bulletin, No. 57A, lists a wide range of machine tools made of Ampco Metal, an aluminum bronze alloy, and includes typical applications. Ampco Metal, Inc. (3)

Creep Stress Data. A new data card issued by Babcock & Wilcox Tube Co. graphically shows creep stress data for B & W Croloy 2¼ and approximate comparison of creep strength data for the various resistant B & W Croloy steels. (4)

Saturants for Wire Insulation. The forms, properties and uses of Zyrox Brand saturants for treating fibrous materials, used in insulating electrical wire and cables, are described and illustrated in a 16-page bulletin, No. W-9, issued by Bakelite Corp. (5)

Cellulosic Plastics. Complete data on a variety of Celanese cellulosic plastics, produced by Celanese Plastics Corp., are presented in a 12-page, illustrated bulletin. (6)

Brass Die Castings. Numerous case histories concerning the brass die castings produced by Doehler-Jarvis Corp. are presented in a 4-page, illustrated bulletin. (7)

Spiral Cam Fasteners. Typical applications of a variety of spiral cam fasteners for fastening hinged or removable parts are discussed in a 4-page, illustrated bulletin, issued by Dzus Fastener Co., Inc. (8)

Protective Coating. Spray-Peel, a plastic strippable compound easily applied by brush or spray for protection against moisture, abrasion, oils, acids, etc., is discussed by the Eronel Industries in their 2-page, illustrated bulletin. (9)

Calculator for Tubing Stock. The Peter A. Frasse & Co., Inc. has just issued Data Chart No. 3 on how to calculate the proper size of seamless steel tubing stock that will finish to final dimensions with minimum of waste. (10)

Aluminum Castings. Specifications, composition and typical properties of a number of aluminum permanent mold and sand casting alloys are included in this 12-page, illustrated bulletin offered by General Aluminum Mfg. Co. (11)

Protective Coating. This single sheet, No. 5566, discusses Cocoon Black No. 9, a black, strippable coating rapidly applied by standard spray equipment that protects metal surfaces against corrosion in shipping or storage. R. M. Hollingshead Corp. (12)

Castings. The extensive, modern facilities of Howard Foundry Co. for producing aluminum, magnesium, semi-steel, bronze and brass castings and patterns are profusely illustrated and described in an attractive, 54-page catalog. Specifications, compositions and mechanical properties are included. (13)

Bronze Bushings, Bearings, Etc. A complete stock list of bronze bushings, bearings, bars and babbitt is offered by Johnson Bronze Co. in an 80-page, illustrated catalog, No. 460. Specifications are included. (14)

Powdered Metal Parts and Bearings. Specifications and typical applications are included in this 44-page, illustrated bulletin concerning powdered metal parts and bearings produced by Keystone Carbon Co. (15)

Plastic Gears. Information on how to make gears with Lamicoid, a laminated phenolic plastic, that range in size from less than 1 in. in pitch dia. to several feet, is presented in a booklet just published by Mica Insulator Co. (16)

Miniature Ball Bearings. Five types of miniature ball bearings for precision instruments and mechanisms are described in a 4-page, illustrated bulletin, No. 4b-1, offered by Miniature Precision Bearings, Inc. Specifications and applications are included. (17)

Resin Coating. Technical aspects, applications and uses of Nukemite, an acid- and alkali-proof resin coating produced by Nukem Products Corp., are discussed in a 12-page, illustrated bulletin. (18)

Fibers, Mats and Cloths. This four-page, illustrated bulletin discusses the use of Fiberglas fibers, mats and cloths with plastics in consumer and industrial products. Owens-Corning Fiberglas Corp. (19)

Corrosion Resistant Coating. Iridite, a quick dip process for corrosion resistance as a paint base or final finish on all zinc or cadmium surfaces, is discussed in a 4-page, illustrated bulletin offered by Rheem Research Products, Inc. (20)

Metal Fabrication. The facilities of W. S. Rockwell Co. for fabricating all kinds of sheet and plate in a variety of sheet metal products, welded assemblies, special machines, etc., are discussed in a 4-page, illustrated bulletin, No. 427. (21)

Flexible Shafting. This 20-page, illustrated bulletin, just released by Walker-Turner Co., discusses the construction, characteristics and application of flexible shafting designed to specifications for aircraft instruments, appliances, industrial machinery, and other special uses. (22)

Methods and Equipment

Foundry Mechanized Equipment. A wide range of mechanized equipment for the modern foundry designed to produce better, lower cost castings is described and illustrated in a 20-page bulletin, No. 07B6092A, available from Allis-Chalmers Mfg. Co. (23)

New Materials and Equipment

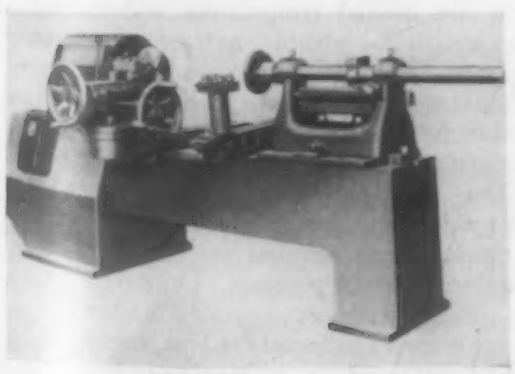
Spinning Lathe Designed for Secondary Forming

New second operation spinning lathes to bulge, neck, bead, wire, flange, curl, and trim a variety of drawn or spun shells have been introduced by *E. W. Bliss Co.*, Detroit 2. Not recommended as an alternative to the toggle press for producing shells from flat disks, these lathes are primarily intended to supplement the latter machines by rapidly accomplishing secondary spinning operations on products previously drawn in presses, and at a rate commensurate with the primary operation.

A combination multiple-disk friction clutch and brake is provided for stopping and starting, which, together with the fast acting tail-stock toggle clamp, permits rapid loading and unloading of the machine. The tail-stock's offset adjustment allows use of inside form rolls to replace the more expensive and slower sectional chucks that are used for many necking operations.

Lateral and longitudinal handwheel control of the compound rest provides maximum rigidity for the frictionless spinning and burnishing tools, and minimizes the manual dexterity necessary for consistent, long-run production. Other attachments include a wiring rest, operated by a tilting lever, that can be pivoted to approach the work from any desired angle. Also available are a standard tilting rest for combination trimming and wiring, and a special trimming attachment for straight shells without flanges.

The new lathes are offered in two sizes, with up to 30-in. swing and 92-in. bed-length. Headstock spindles run on Timken bearings at the following variable speeds: Model number 15 at 275, 365, 615 and 1140 rpm.; model number 16 at 180, 370, 675, and 1140 rpm. The lathes weigh 1500 and 300 lb., respectively.



One of a new line of second operation spinning lathes to supplement toggle presses.

New Compounds Aid Forming and Welding Operations

Two new processing compounds—one for welding operations, and the other a metalworking lubricant—are being marketed by *G. W. Smith & Sons*, 5400 Kemp Rd., Dayton 3, Ohio.

The arc welding compound is an electrically conductive composition of inorganic minerals which supplements the fluxing action of the welding rod coating. It stabilizes and quiets the welding arc, prevents arc breakage, and is said to improve fusion and prevent scale on both sides of the weld bead. It also prevents adhesion of weld spatter to parts being welded.

The compound, known as POM, contains no oils or other combustible ingredients and therefore causes no smoke, fumes, or odors under the heat of the welding arc. The compound is supplied as a paste which is thinned by the user with an equal part of water and is brushed or sprayed into the seam to be welded and on adjacent surfaces where spatter usually collects. After welding, the spatter and compound are wiped off with a dry cloth. It also contains a rust inhibitor so that it can be applied to the steel at any time before welding and will protect the parts from rust until they are fabricated.

The metalworking lubricant, known as Die Slick No. 5, is for use in forming operations at high pressures and/or high temperatures. For use on ferrous or nonferrous metals it has been found effective for such applications as hot drawing, hot piercing punches, hot forging, deep drawing, and for numerous other jobs to prevent scoring and sticking of metal being formed.

The lubricant will withstand pressures of more than 100,000 psi. and can be used with temperatures up to 2300 F. The compound will not discolor the work pieces, is noncorrosive, non-carbon-forming, and causes no objectionable smoke or gases. It contains no graphite.

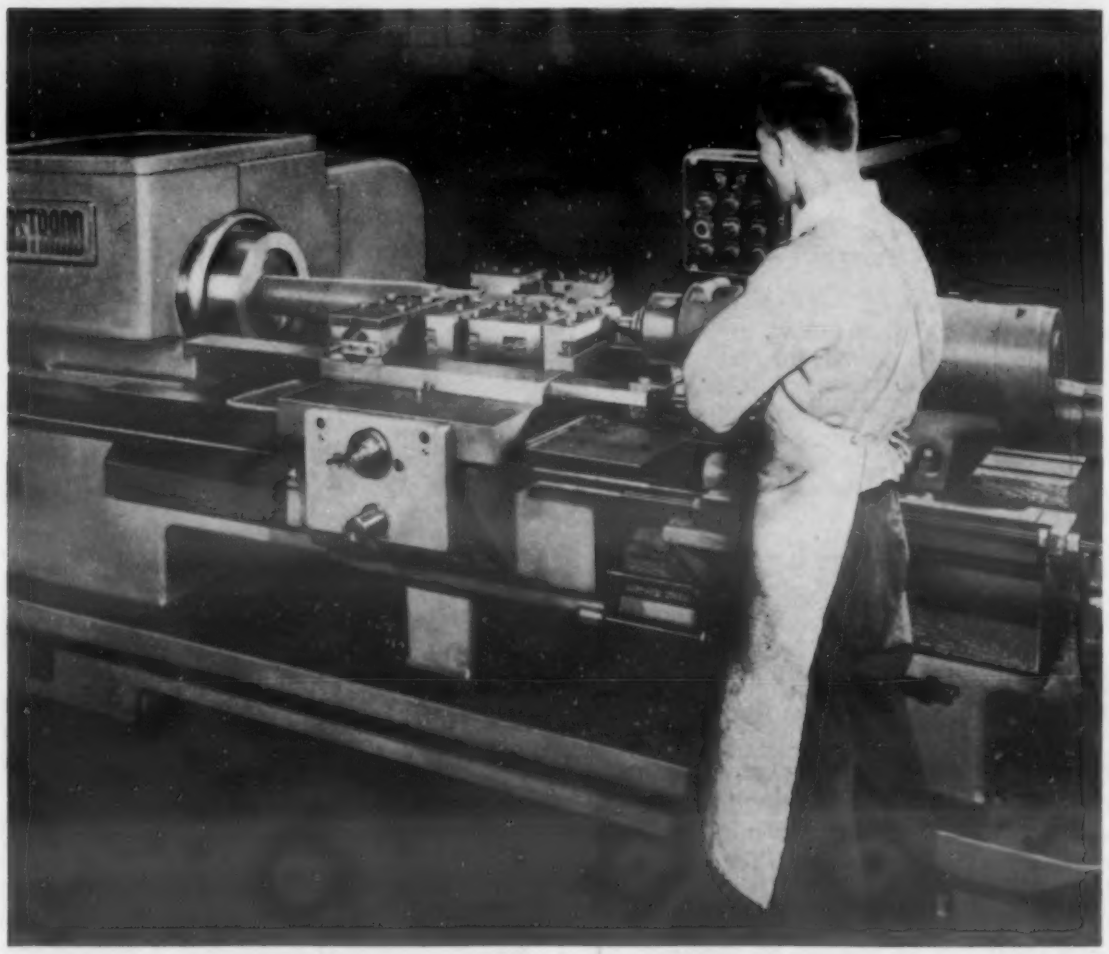
New Automatic Lathe Has 75-Hp. Spindle Drive Motor

A new model automatic lathe has been added to their present line of lathes by the *Sundstrand Machine Tool Co.* of Rockford, Ill. The lathe is provided with a 75-hp. motor. It has a 17-in. swing over slides, will swing a 21-in. dia. chuck. Machines can be furnished in three bed lengths of 36, 60 or 84 in. between centers.

The quick cycle changeover makes it possible to multiple tool this lathe for short runs as well as for production turning. It can be used for either shaft turning jobs or chucking work. The horsepower rating makes it practical to use multiple tooling and carbide cutting tools.

Both the spindle and front carriage drive units are provided with two different driving gear centers. In each case, this provides an increased range between high and low spindle speeds and high and low front carriage feeds. In addition, the number of speeds and feeds obtained from one set of gears are both doubled.

Control of all cycles is provided by adjustment of dogs on a cycle control disk. Making cams for cycle control is thereby eliminated. Changing position of dogs on disk changes length of rapid approach, feed and rapid return strokes. This simplifies cycle setup.



New model Sundstrand lathe can be used for either shaft turning jobs or chucking work.

Seamless Moly Tubing Commercially Available

Seamless molybdenum tubing is being produced in commercial quantities for the first time, according to *Callite Tungsten Corp.*, Union City, N. J. The tubing is available in sizes ranging from 0.040- to 0.500-in. O.D. and in lengths up to 9 in.

This molybdenum tubing is readily machinable and can be worked and shaped within reasonable tolerances. It welds to iron, nickel and similar materials. The tubing is resistant to attack from hydrofluoric acid and hot aqueous solutions of sodium and potassium hydroxide. When sustained in a protective atmosphere, moly tubing will withstand high tensile stresses at elevated temperatures.

The physical and mechanical properties of the seamless molybdenum tubing are as follows:

Purity—99.9% pure molybdenum
Specific gravity—10.2
Melting point—4740 F
Tensile strength—From 180,000 to 250,000 psi., depending upon dia.
Hardness—160-185 Bhn (10-mm. ball 3,000-kg. load).
Thermal expansion—25 to 500 C (4.7-5.7) x 10^{-6} per °C
Thermal conductivity—1.46 w. per cm/°C at 20 C

Knee-Type Miller Designed for Small Parts Production

For manufacturers of small parts and for tool and die shops, *Childs & Co.*, 271 16th St., Conneaut, Ohio, are manufacturing a knee-type milling machine.

The basic unit, 14½ in. high, may be used for bench or table model operations or when used with the pedestal base, it provides a floor-type milling machine. The capacity of the unit is indicated by the following feeds: longitudinal 6 in., transverse 1½ in., and vertical 4 in. Movement of the table in transverse, longitudinal and vertical directions is held to 0.001 in. in accuracy.

A countershaft and jackshaft with V-belt pulleys provide nine changes of speed. The countershaft assembly, which is available in the pedestal base, provides speeds from 280 rpm. to 11,150 rpm.

The spindle is driven by V-belts from the countershaft. The overarm is solid rectangular type sliding in scraped dovetailed ways, clamped in place by two locking levers. Four adjustable dials are graduated in 100 graduations, each graduation being 0.001 in. All feed screws are of Acme form thread.

A ½-hp. motor is generally recommended, but if only lighter cuts are to be made, a ⅓- or even ¼-hp. fractional motor may be used. The unit weighs 75 lb.

● A new cutting fluid claimed to be the only soluble cutting oil which combines, together with all-water miscibility, the qualities of high lubricating value, extreme stability, pleasant odor, and non-foaming and rust preventive characteristics, has been announced by *Gulf Oil Corp., Pittsburgh.*

Pyrometric Controller Uses New Electronic Circuit

A new pyrometric controller, announced by the *Taco West Corp.*, 2620 S. Park Ave., Chicago, is a two-position electronic controller specially suited for direct installation on industrial furnaces and plastic molding machines.

In operation, the control pointer is set at the desired temperature and control is established within narrow temperature range. The design permits the instrument movement to operate a heavy duty relay system without any physical contact or reaction effect on the indicating pointer. The relay is built in and has a load capacity of 3 kw. non-inductive. The electronic circuit requires no tuning or other adjustments by the user at any time.

The electronic control mechanism is stable and unaffected by line voltage variation, surge effects, tube aging or component changes. A pointer movement upon scale of 0.002-in. produces exacting relay operation. The measuring system is compensated for cold junction deviation, moving coil temperature coefficient, and magnetic errors.

Direct Reading Spectrometer Makes Analysis in 2 Minutes

Rapid and completely automatic analysis of various elements in a metal alloy is possible with the direct reading spectrometer manufactured by the *Baird Associates,* 33 University Rd., Cambridge, Mass. This is accomplished by measuring electronically the intensity of spectrum lines.

The new instrument eliminates necessity for photographic and developing equipment encountered in ordinary spectrographic techniques. Only one technician is required to operate the instrument. The spectrometer and the measuring system are integrated into one compact unit. At one commercial alloy plant using this instrument, samples are currently being run at a rate of 4000 per month, representing approximately 20,000 quantitative determinations.

Individual spectrum lines necessary for analysis can be isolated even in the complex iron spectrum, and their intensity measured with electron multiplier photo-tubes. The output current of the tubes charges a capacitor, which at the proper time, discharges into a meter reading directly in percentage concentration of the alloying and residual constituents.

The grating spectrometer is equipped with electron multiplier photo-tubes allowing the simultaneous determination of a number of elements, using the internal standard method. Light intensities are integrated over a sparking period of 20 to 30 sec. by storing the photo-currents in suitable condensers, or "capacitors." Analytical results are obtained automatically in a 10-sec. recording interval immediately following the sparking period.

● The *Indar Corp.,* 910 E. 23rd St., Indianapolis, Ind., has announced a hydrogen-reduced molybdenum powder of high purity and very fine particle size. In addition to molybdenum powder, developments on tungsten carbide powder have resulted in a product which is extremely low in free carbon and has a small particle size. This powder is suited for the manufacture of carbidic cutting tool materials and similar applications.

Polishing and Buffing Lathe Features Overhanging Base

A new model single-speed polishing and buffing lathe that has an overhanging base to provide liberal working space around the wheel has been announced by *Hammond Machinery Builders, Inc.,* 1600 Douglas Ave., Kalamazoo, 54, Mich. The lathe will accommodate either a 2- or 3-hp. motor and is multi-V-belt driven from the motor mounted inside the base.

The spindle overhangs 8 in. Any single spindle speed from 1200 to 3600 rpm. can be furnished. The lathe is designed for finishing small parts, color buffing, brushing and light cut buffing and polishing.

This model is furnished with magnetic motor control. Both ends of spindle are tapped for taper points. The standard arbor size is 1 or 1¼ in. The floor space required is 47 by 33 in.

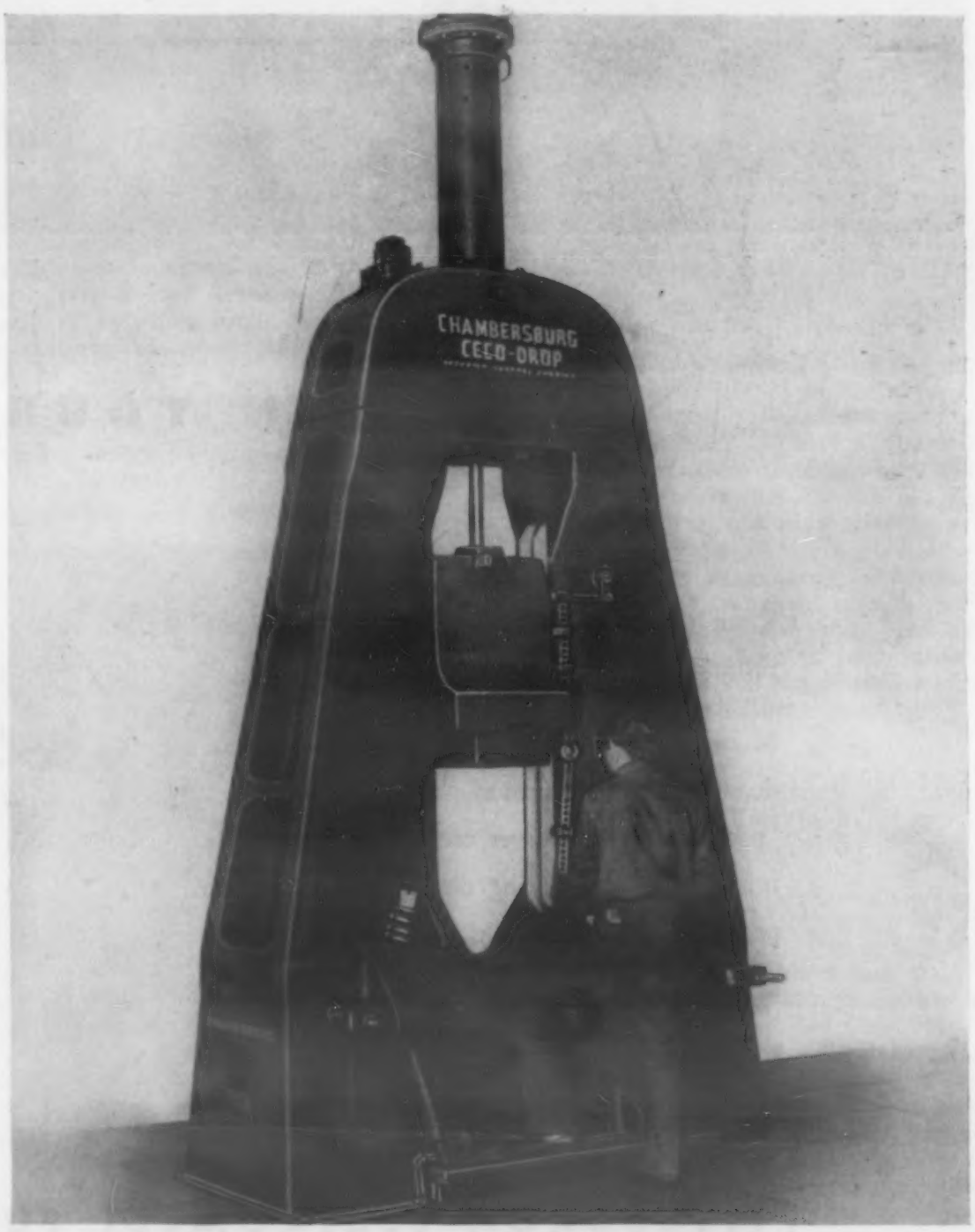
Drop Forging Hammer Eliminates Friction Lift

A new gravity drop hammer that, unlike the conventional board drop hammer, employs no boards or other form of friction lift, has been announced by *Chambersburg Engineering Co.,* Chambersburg, Pa. Air or steam is used to raise the ram. A clamp holds ram and rod at the top of the stroke. The clamp is released by means of an air valve actuated by the operator's foot treadle.

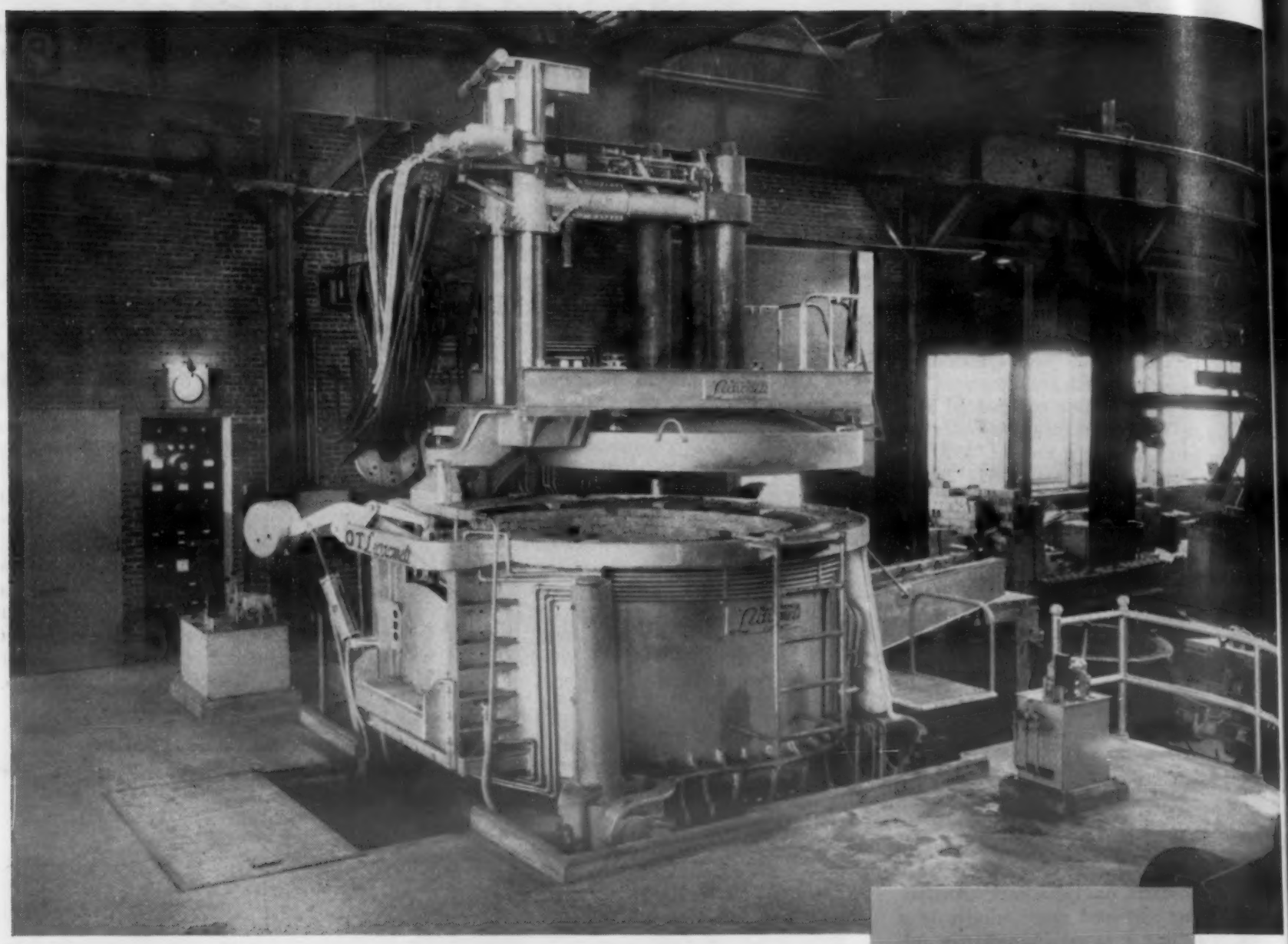
Because of its speed, the metal is forged at higher temperatures, and forgings are said to be matched through the use of parallel, integral guides, heavier frames, and a low center of gravity which insures against movement and vibration.

There is no friction to adjust and the stroke can be changed by means of a rocker arm with adjustable dogs. There are no parts overhanging the operator and no front rod with heavy knock-off, release lever and dogs. The hammer is equipped with a simple rocker arm with light weight dogs adjustable with spring clips to holes in the rocker arm.

The clamp cylinder is actuated by a pneumatic pilot valve on the operator's treadle. Feeding and working zone is clear and free due to the elimination of the front rod and its appurtenances. The manufacturer offers a range of sizes from 50 to 20,000 lb.



This drop hammer utilizes no boards or other form of friction lift.



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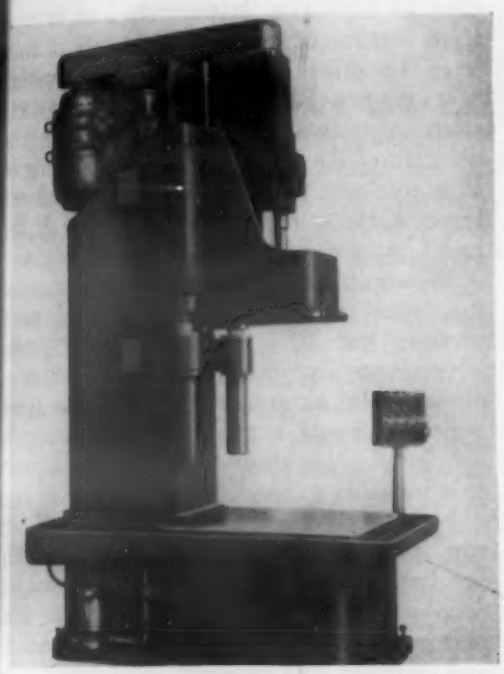
Drilling Machine Adaptable to Special Purposes

A new automatic drilling machine, designed and built as a standard machine tool specifically for special purpose adaptations, has been announced by the *Robbins Engineering Co.*, 318 Midland Ave., Detroit 3.

Tooling heads are mounted on the machine saddle by means of standard locating and hold-down holes. Any number of spindles may be included in the head and all are driven by the machine spindle. When operations change, the head can be removed and a new one mounted in its place.



With this flexible automatic drilling machine, special purpose adaptations can be made.

The ways, consisting of two alloy steel guide bars, are gripped in the saddle, making the saddle and bars an integral unit. The saddle is operated by a ram from the hydraulic unit mounted on the machine column above the saddle. Thus, the hydraulic pressure is directly over the work, eliminating friction on the guide bars due to tool thrust and adding to the smooth operation of the machine.

The guide bushings are located on the machine column so that as the saddle feeds into the work, it approaches the bushings. Thus, when the tools are cutting, the saddle is adjacent to the guide bushings and therefore has maximum support.

The hydraulic power for the drill is supplied from a self-contained unit mounted at the top of the machine column. The hydraulic pump, pump control mechanism, oil sump and hydraulic cylinder are enclosed. All connections are manifolded inside the unit.

A wide variety of spindle speeds is available by use of the change gears within the unit and also by changing the V-belt cone pulleys on the motor and spindle. The operating cycle can be varied to provide rapid approach, two adjustable rates of feed, dwell and rapid return, and stop.

In addition to the center tooling saddle, auxiliary units may be mounted around the base horizontally, vertically, or any angle in between. By using such auxiliary units several operations can be performed at once and with one clamping of the work.

Face Gage Inspects Threads

A new gage for checking the relationships between the pitch diameter of a thread and the face of the part has been developed by *Bryant Chucking Grinder Co.*, Springfield, Vt. This new squareness-of-face gage can be mounted on any Bryant thread gage. The face gage consists of a movable arm which carries a large dial indicator and two contact points which are adjustable to cover the capacity of the thread gage. The inner contact serves as a pilot and compensates for thread progression as the part is turned for inspection. The front contact actuates the dial indicator on the face gage.

Operation of the gage is as follows: the control lever withdraws the thread segments behind guides, the part is positioned and the three thread segments are engaged; the part is given one-third of a turn for all-over thread inspection, which is recorded visually on the thread gage dial indicator. The squareness-of-face gage is then swung into position and a half turn more checks the right angularity, which is recorded visually on the other dial indicator. The control lever is then actuated, allowing the part to be lifted from the gage, thus eliminating unscrewing the part off the thread segments.

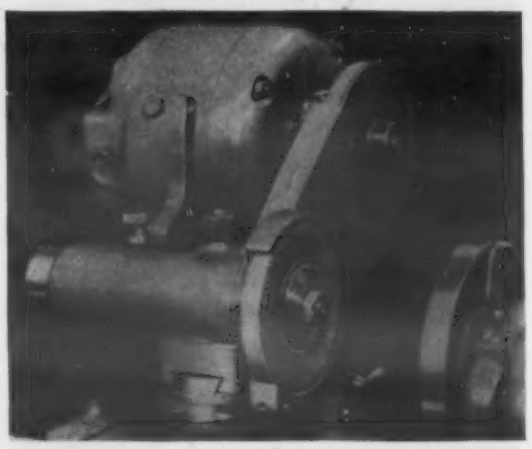
No "feel" is necessary for inspecting the threads or their squareness to the face. Various models cover capacities from ⅜ in. to 8 in. internal.

Unskilled operators can run this gage at high speed and with accuracy.

Lathe Grinding Attachment for Precision External Grinding

An electric grinding attachment for use on lathes and other machine tools has been developed by the *South Bend Lathe Works*, 326 E. Madison St., South Bend 22, Ind. Designed primarily for precision external grinding, it is equipped with a 4-in. by ½-in. grinding wheel which is driven by a constant speed continuous duty ¼-hp. motor. This permits taking heavier sustained cuts than would be practical with a universal type motor of the same rated horse power. This grinding attachment can be adapted to most makes of lathes, milling machines, shapers, planers, etc.

The grinding wheel spindle runs on prelubricated sealed ball bearings. Tension adjustment is provided for the V-belt which connects the motor with the grinding wheel

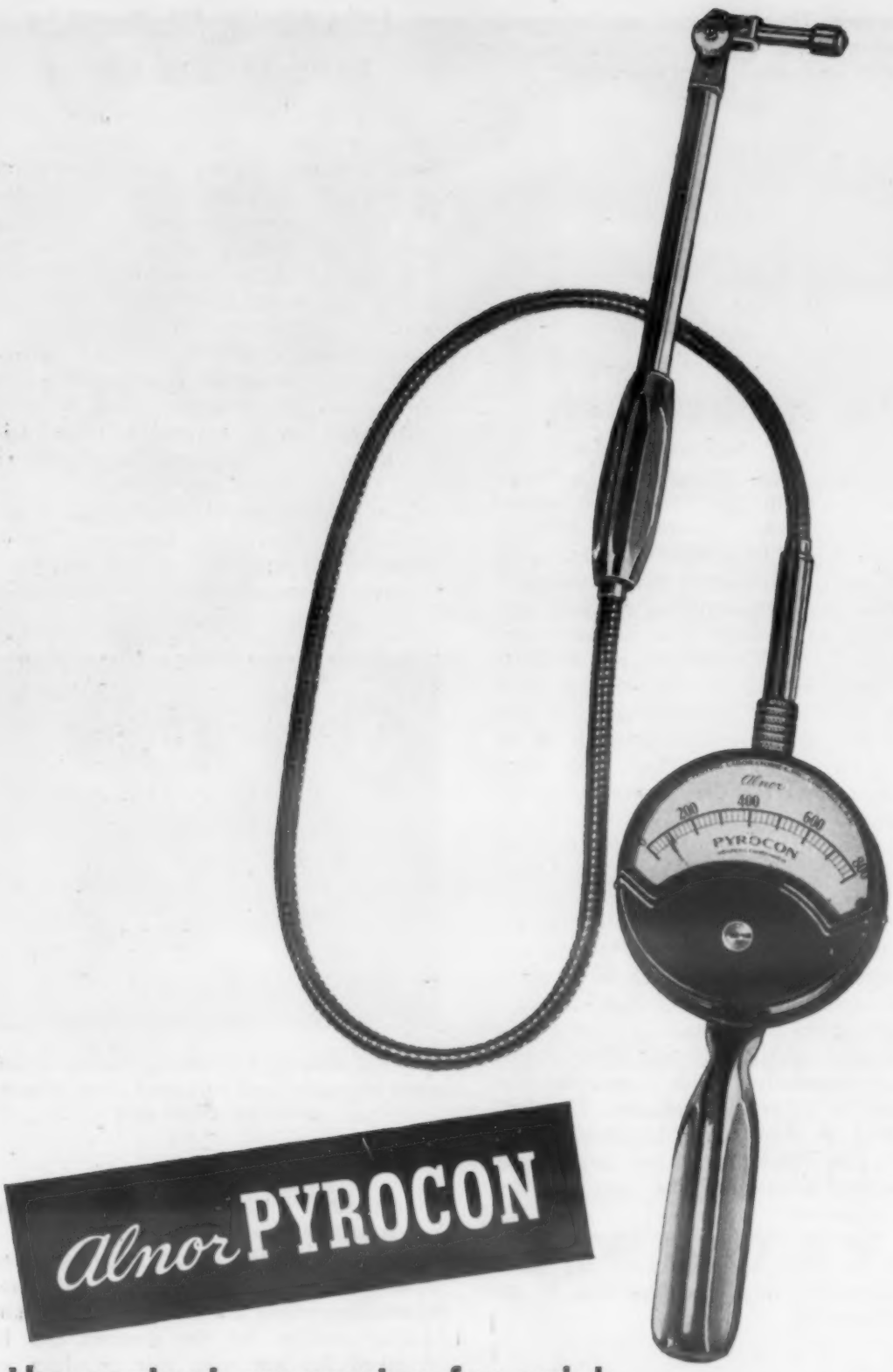


The ball bearings in this grinding attachment are sealed and protected from abrasive grinding wheel dust.

spindle. Both the grinding wheel and the V-belt are enclosed in a single guard.

Spring stops for grinding straight and spiral fluted reamers and cutters, diamond dressers for truing the grinding wheel, and holding fixtures for the dressers can be furnished for use with this grinding attachment. Grinding wheels are available in several grades for grinding various materials, including tungsten carbide, tool steel, machine steel, cast iron, brass or bronze, aluminum, Bakelite, hard rubber, and soft rubber. Special cup wheels are supplied for reamer and cutter grinding.

● A complete line of open-back inclinable punch presses is now in production at the *Vernon Press Div., Ran Corp.*, Richmond, Calif. Features of the Vernon press include a rigid one-piece frame of exceptionally heavy section to assure protection against distortion from overloads. Accurately-machined gibs are extra long to provide lasting accuracy; the entire press is designed for precision, heavy-duty service and long operating life with minimum maintenance expense.



Almor PYROCON

the contact pyrometer for quick, accurate surface temperatures

Designed to meet foundry and industrial plant needs, this all-purpose surface temperature pyrometer provides readings in a few seconds of molten metals, liquids, bulk materials, and flat or curved, stationary or moving surfaces. The rugged, shock-resisting pyrometer movement may be used with any of eight standard thermocouples, interchangeable without adjustment or re-calibration. Choice of rigid or flexible arms. Built in several standard scale ranges, 0-300 to 0-1200 F. Write for bulletin with complete description.

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New Finishes and Coatings Introduced for Many Uses

Protective coatings and finishes are constantly being introduced to improve the appearance and corrosion resistance of metal products. Some of those recently announced are described below.

Anti-Rust Compounds

Two new anti-rust products announced by the *Yosemite Chemical Co.*, 1040 Mariposa St., San Francisco, are applicable to iron, steel or nonferrous metals. The products, both liquids, are known as Y-3 and Y-600.

Y-3 rust remover is a clear, non-oily fluid that may be applied by sponging, dipping or brushing. It removes rust or stains from ferrous or nonferrous metals in from 3 to 15 min. At the end of this period rust may generally be wiped off with a damp cloth. Abrasives are not necessary except in the case of deep rust-pitting. Depending on time allowed to stand, the compound will leave a clear, invisible film, or a darker, more porous film.

When applied before priming and painting, tests have shown that painted metal surfaces last 30% to 60% longer, under adverse weather conditions. The compound also contains an anti-rust or anti-stain agent which prevents rusting for periods up to 10 days. In this short-term anti-rust capacity it is valuable to sandblasters.

For maximum rust prevention, Y-600 rust preventive may be used. This fluid can be sprayed, dipped, painted or sponged onto metal surfaces—dry or wet. It dries within 6 hr. The resulting film is elastic and uniform, and prevents rust around dents, nicks or scratches in the treated surface.

This compound is equally effective for preventing corrosion and stain on nonferrous metals. It halts tarnish on polished copper, bronze, brass, Monel or chromium plated surfaces. It forms a hard, heat-resisting film which is all but invisible on engine-parts, fittings or other machine gear.

Oxidized Finish

A new material for producing a black-to-gray oxidized or "antiqued" finish on sterling and silver-plated products is being produced by the *Hanson-Van Winkle-Munning Co.*, Matawan, N. J. No electric current is required. The work is immersed in the solution, known as Platin-Nig. The parts are then high-lighted for light-and-shadow relief.

The stock solution is diluted with distilled water to produce solutions that vary in density between 3 deg. and 7 deg. Bé, depending upon the depth of color desired. Flatware is heated to a point where it can just be handled without discomfort and brushed with the solution until the desired color is obtained.

Anti-Corrosive Process

An anti-corrosive process which is said to afford 20 years protection to ferrous metals against all common corrosive forces has been developed by *Industrial Metal Protectives, Inc.*, Dayton, Ohio. Known as Zincilate, it has been used successfully on pipelines, on the interiors and exteriors of water and gasoline tanks and bridges

...d on machine parts.

The protection provided is unaffected ...fter 1,000-hr. exposure in standard salt ...g corrosion equipment, as approved by ...e ASTM. It is a one coat protective ...ating and possesses good abrasion resist...ce. When sizable areas are destroyed by ...usual scraping or wear, protection is ...sured through cathodic sacrifice of the ...m.

...luminum Finish Enamel

A new line of enamels that bake or air ...y to a finish closely resembling brilliant ...luminum have been developed by the *Maas & Waldstein Co.*, Newark, N. J. ...known as Britelume, these enamels can be ...ed on most metals to produce a finish ...t's attractive to the eye and also resistant ... heat and chemicals.

Heat-Resistant Paint

Protection against corrosion and scale ... high temperatures is the chief advantage ... a new heat-proof paint introduced by *Markal Co.*, 607 N. Western Ave., Chicago ...2. It is a functional paint and will pre...ent hot metals from corroding and scaling ... temperatures as high as 1850 F. It pro...ides protection to metals in all weather ...nditions.

The hot metal can be subjected to sudden ...mperature changes such as quenching ...mediately in cold water without cracking ... peeling of the paint, since the paint ...llows the contractions and expansions ... the metal at all temperatures.

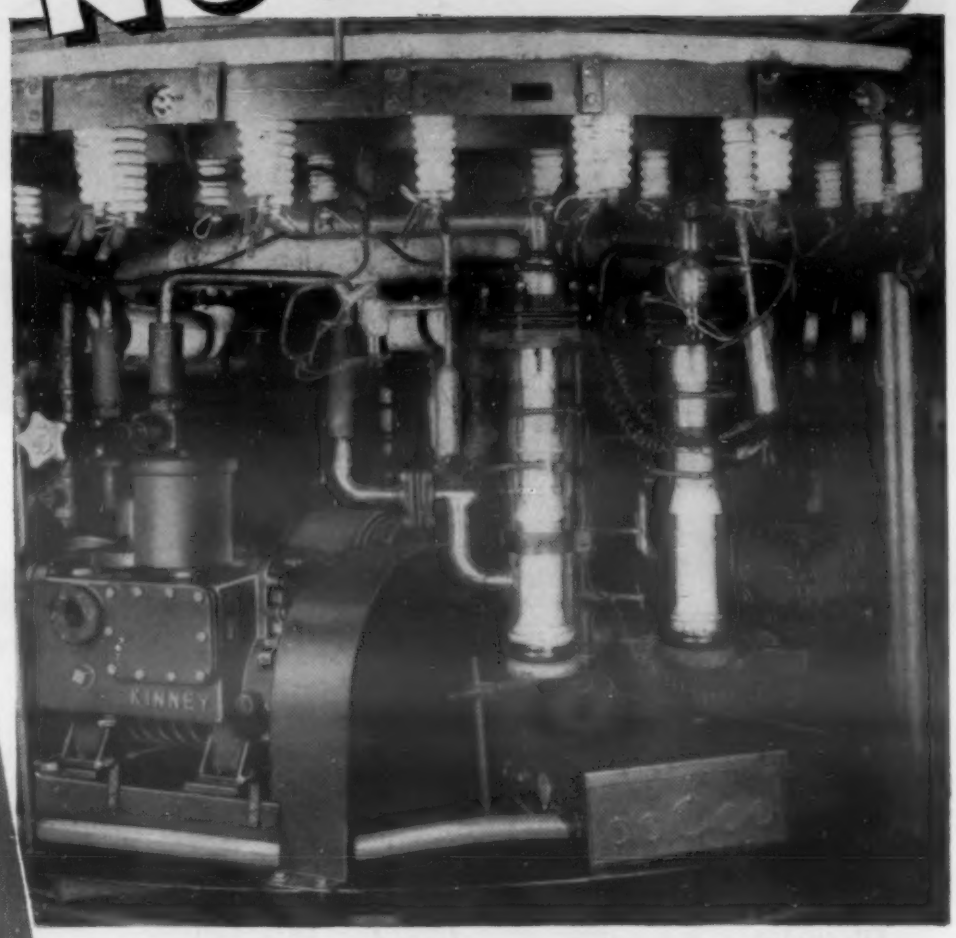
Some of its uses include smoke stacks, ...nealing boxes, exhaust manifolds, furnace ...pes, mufflers on trucks and tractors, etc. ...e paint is applied while the parts are ...ld. It dries in about 20 min. and can be ...bjected to hot temperatures immediately ...fter drying.

Electric Handgrinder Can Be Converted to Flexible Shaft Tool

A new electric grinder for use either as ... straight handgrinder or with an attach...ent which converts it to a flexible-shaft ...ol has been developed by the *Dumore Co.*, ...acine, Wis. The flexible-shaft conversion-...achment includes a bail or hanger, in ...hich the grinder is clamped, a 36-in. ...exible shaft which chucks into the grinder, ...d a choice of three different handpieces. ...e handpieces are designed to provide a ...election according to the requirements of ...e work to be done.

A 1/14-hp. motor equipped with sleeve ...earings supplies the power for this hand...ol. Its chuck has ¼-in. capacity, and can ...e adapted to 3/32-in. and ⅛-in. shank ...ools with collet sleeves provided. It is ...daptable to a variety of jobs in wood, ...etal and plastics—sanding, sharpening, ...inding, sawing, drilling, and polishing.

PRODUCING A LOT OF NOTHING



Compact installation of Kinney Compound High Vacuum Pumps used to back diffusion pumps in the manufacture of ultra high frequency tubes at Raytheon Mfg. Co., Waltham, Mass.

IN A SMALL SPACE

The compact design of Kinney High Vacuum Pumps enables them to be grouped closely with auxiliary equipment . . . shortens pipe lines . . . saves valuable floor space. Kinney Pumps are self-contained units, easily installed. Having automatic lubrication and oil sealing, they produce high vacuums indefinitely with minimum attention.

The faster pump down and lower ultimate pressures of Kinney High Vacuum Pumps shorten production time and cut costs in vacuum processing—exhausting lamps and tubes, sintering alloy metals, coating lenses, producing drugs, etc. Kinney Single Stage Vacuum Pumps produce low absolute pressures to 10 microns; Compound Pumps to 0.5 micron.

Write for Bulletin V-45.

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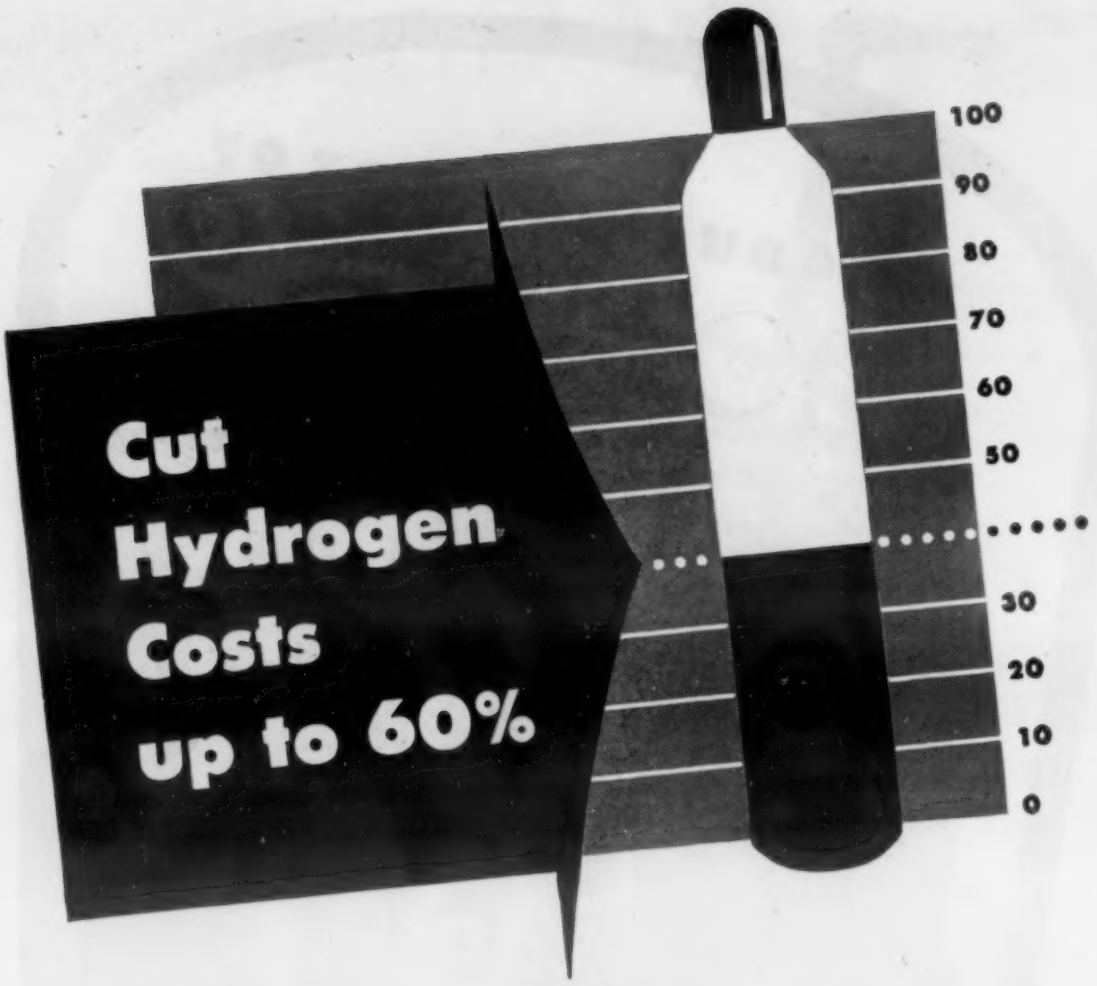

1 Cylinder of Ammonia When Dissociated Equals 34 Cylinders of Hydrogen!

Hydrogen may be replaced by dissociated ammonia for many metal treating applications with cost savings as great as 60% for some users. Because one cylinder of ammonia when dissociated supplies as much gas as approximately 34 cylinders of hydrogen, the cylinder handling and storage problem is greatly reduced.

Dissociated ammonia as a source of hydrogen has these additional advantages: (1) Lower moisture content results in brighter work; (2) Lower pressure simplifies control and decreases hazard.

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New Small Electric Furnaces Have Automatic Heat Control

New models of small electric furnaces have been introduced recently by two manufacturers. A new model, developed from one of the company's previous models and featuring a new type of stepless heat control, has been announced by the *Thermo Electric Manufacturing Co.*, Dubuque, Iowa.

With this model the furnace temperature can be raised or lowered by moving a control knob to right or left. Temperatures between 500 and 1850 F can be selected and automatically maintained. This control is said to have an advantage over the synchronous motor-driven type of input controller in that it is nearly 100% compensating for normal fluctuations in line voltage, and is available for use on direct current as well as alternating current of any cycle.

The inside dimensions of the furnace are: 4 in. wide, 3-¾ in. high and 3-¾ in. deep. It is equipped with an indicating pyrometer calibrated in both Fahrenheit and Centigrade scales. The heating element is coiled from heavy gage alloy, and is embedded in the sides, top and bottom of the heating chamber to provide both greater protection for the heating element and more uniform distribution of heat. The body and door are one-piece aluminum castings; the unit weighs 15½ lb.

A new medium-size laboratory furnace, with built-in automatic temperature controls, has been developed by *K. H. Huppert Co.*, 6830 Cottage Grove Ave., Chicago 37. With over-all dimensions of 19 in. by 20½ in. by 21¼ in., the furnace maintains any temperature automatically between 250 and 1900 F, and reaches a maximum of 2000 deg.

This K. H. Huppert furnace, applicable to laboratory and small production work, has built-in automatic controls.

The heating unit consumes 2,000 watts at 110 v. (a.c. only), and is constructed of heavy gage special alloy wire. The furnace itself is made of heavy gage steel, with multi-layered insulation, and finished in baked black wrinkle enamel. Inside dimensions are 6 in. by 6 in. by 6 in., with a 3¼-in. throat additional. The complete furnace, including automatic heat controls, weighs 148 lb.

Dual Purpose Machine Grinds and Finishes Tools

A combination chip breaker grinder and diamond finishing grinder that can handle all types of box and single point tools has been announced by *Hammond Machinery Builders, Inc.*, Kalamazoo 54, Mich. It provides chip breaker grinding on the one side and diamond wheel finishing on the other.

On the chip breaker side are the necessary movements and angular settings required for chip breaker grinding. The movements are: vertical with handwheel and dial calibrated to 0.001 in.; traverse in and out from wheel with handwheel and dial calibrated to 0.001 in. and reciprocation underneath wheel with a lever operated table. A vise provides all the necessary angular settings with four swivels, each of which is graduated in degrees.

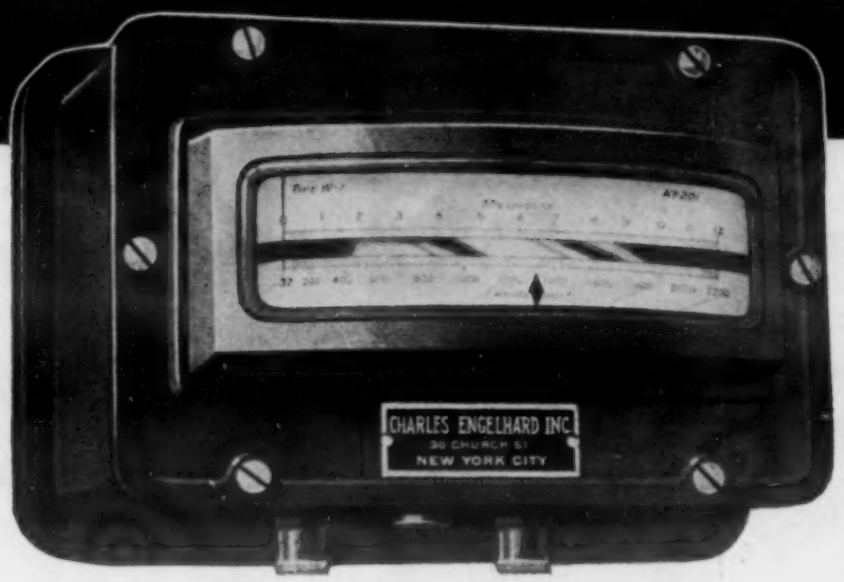
Chip breaker grinding and finishing can be performed on this dual purpose grinder.

The cup wheel side accommodates either 6- or 7-in. dia. cup wheels and has a tilting table assembly. The table tilts to any point between 25 deg. above to 30 deg. below horizontal. It is moved in and out from the wheel by a feed screw. The table dimensions are 8 by 14 in.

A drip feed tank supplies the two wheels by use of a tube for the cup wheel and a wick for the straight wheel. The spindle is driven by a V-belt from a ½-hp. motor in the base. Spindle speed is 3150 rpm.

● Two new series of gas-fired crucible furnaces for melting brass, bronze, aluminum and other alloys are being offered by *Eclipse Fuel Engineering Co.*, Rockford, Ill. The "RB" series stationary furnace is designed for heavy foundry production; the "SB" series is planned for similar purposes, but incorporates the "HE" entrainment burner, which accurately maintains a constant air-gas ratio over an extremely wide turn-down range.

Unconditional Sensitivity!



ENGELHARD

INDICATING PYROMETERS

Despite severe operating conditions, the Engelhard Switchboard model (above) responds with delicate sensitiveness to variations of 55/1,000,000 of one volt in order to show temperature changes of 10° F! Accuracy is assured by a high resistance per millivolt that is unaffected by the length of connecting leads or by thermocouples of different resistances. In addition, a sturdy case and heavy inner construction provide permanent efficiency for unusually difficult services.

Readings by direct deflection are made simply and *instantaneously* in either millivolts or temperatures. This model can be calibrated with two ranges for one type of thermocouple, or for two types of thermocouples in any combination desired. It is provided with a zero adjustment device to allow setting for ambient temperature variations.

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CHARLES ENGELHARD, INCORPORATED
90 CHESTNUT ST., NEWARK, NEW JERSEY

Banish Fear

OF COSTLY SHUT DOWNS

with THERMALLOY

HEAVY DUTY

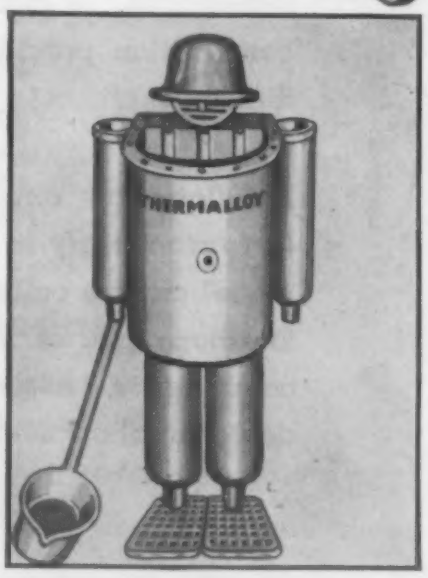
PIN LOCK

CHAIN

Notice the simplified construction of three part (patented) PIN LOCK CHAIN and compare with the chain you are using. Notice too absence of rivets and cotters—simplified assembly. Little slack required for assembly.

This chain design permits full utilization of THERMALLOY high physical properties. Optimum strength and ductility at high temperatures are the result of extensive research and close metallurgical production control.

MUFFLES—RETORTS—POTS
FLEX BOXES—BASKETS—TRAYS
AND FURNACE PARTS



AMSCO ALLOY *and* **THERMALLOY** *are identical*

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION

ELYRIA, OHIO.

Indexing Table Developed for Heavy Workpieces

An indexing table, designed to support heavy workpieces without deflection, is being manufactured by the *Kaukauna Machine Corp.*, Kaukauna, Wis. It was originally developed for use with their series 125 portable horizontal drilling and tapping machines, but is adaptable for use with many other types of machine tools. It is also suited for inspection or layout work.

The main bed is of heavy ribbed cast iron construction, with T-slots, provided in the top and at each end for clamping purposes. Thus, work can be held in either the horizontal or vertical plane. It is also possible to make a set-up on one end of the table while work is being completed at the other end.

A 36-in. dia. indexing platen, manually operated and which can be locked in any position, is in the center of the main bed, supported by a ball thrust bearing. A hardened steel plunger and hardened steel bushings assure positive indexing positions.

This heavy-duty indexing table can be adapted to inspection and layout work.

T-slots in the platen are provided for workpiece clamping, and two adjustable shoes clamp the platen firmly in position.

The overall dimensions of the indexing table are 72 in. long by 36¼ in. wide, and standing at a height of 29 in.

Rubber Insulated Grids Protect Plating Tanks

Rubber linings of plating and pickling tanks can be protected with new seamless rubber covered mesh grids offered by *Automotive Rubber Co., Inc.*, 8619 Epworth Blvd., Detroit 4. Tank linings and agitation coils are protected by these rubber insulated grids against damage by heavy or sharp parts which may be dropped in the tank, or by contact from baskets and handling equipment. The seamless rubber coating also prevents contamination of the plating solution that results from corrosion of exposed metal equipment.

These new grids are constructed of expanded metal reinforced with angle iron and supported on heavy channel iron. Lifting eyes are provided for easy removal to clean tank and for retrieving fallen parts.

New Welding Electrodes Announced

Below are brief descriptions of some recently announced welding electrodes for a variety of applications.

A line of stainless steel electrodes in a full range of grades and diameters has been announced by *Air Reduction Sales Co.*, 60 East 42nd St., New York 17. The electrodes have an extruded lime type coating for d.c. application. In addition, all but the straight chrome analyses are obtainable with a lime-titania type coating which is usable on a.c. or d.c.

Using these electrodes on a.c. is said to eliminate arc blow and result in easier manipulation, more uniform arc action, and better appearance of deposit. This class of electrodes can be recommended for all applications on which the lime type of electrode is used, with the exception of highly restrained joints on heavy sections or on steels of high hardenability.

For welding of mild steel in all positions and with alternating-current or either polarity direct-current, straight preferred, the new SW-2 electrode is announced by the *Westinghouse Electric Corp.*, P. O. Box 868, Pittsburgh 30. The electrode is available in four diameters from 3/16 to 5/16 in.

Welds made with this electrode meet the requirements of AWS-ASTM specifications for classifications E-6012 and E-6013; they are said to have desirable characteristics in respect to flat contours, side wall washup, freedom from undercutting, and ease of slag removal.

For direct-current reverse polarity welding only of low alloy cast steel or low alloy high tensile strength rolled steels in all positions, Westinghouse has announced their new AP-MO electrode, available in three diameters from ⅛ to 3/16 in. This electrode is designed for making butt and fillet welds in all positions, and welds made with it meet the requirements of AWS-ASTM tentative specifications for Iron and Steel Arc Welding Electrodes Classification E-7010.

A new shielded-arc coating has recently been developed for the five grades of Ampco-Trode "AC" aluminum bronze electrodes produced by *Ampco Metal, Inc.*, 1745 S. 38th St., Milwaukee 4, Minn. The electrodes are said to strike easily and do not "snuff-out" on alternating current welding. Spatter loss has been reduced and manipulative characteristics have also been improved for welding with reverse (positive) polarity, direct current.

These electrodes can be used in welding cast irons, malleable irons, aluminum bronzes, silicon bronzes, some nickel alloys, and dissimilar metals with alternating current transformers having a 75-85 open circuit voltage and direct current generators.

A new line of mild steel and low alloy-high tensile steel electrodes, known as Weld-Arc, has been introduced by *Alloy Rods Co.*, York, Pa. The electrodes are manufactured in ten types; six for mild steel and four for low alloy-high tensile. Some of the advantages claimed for these electrodes include: easy slag removal, low spatter loss, high physical properties, correct penetration, quiet arc action, no porosity, no underbead cracking, excellent appearance, and correct contour.

All-State Welding Alloys Co., Inc., 96 West Post Rd., White Plains, N. Y., has announced the availability of a new brazing

Your best source of NH_3

Barrett standards of consistent purity, uniform dryness, speedy deliveries and dependable service make Barrett Anhydrous Ammonia your best source of NH_3.

Barrett Anhydrous Ammonia is available in two grades: REFRIGERATION GRADE, guaranteed minimum 99.95% NH_3; and COMMERCIAL GRADE, guaranteed minimum 99.5% NH_3. Both grades are shipped in tank cars with a capacity of approximately 26 tons of NH_3. REFRIGERATION GRADE only is also packaged in 25, 50, 100 and 150-pound standard-type cylinders and in 100 and 150-pound bottle-type cylinders.

Barrett Anhydrous Ammonia must pass rigid tests for moisture, non-condensable gases and other impurities, before release for shipment. Cylinders and tank cars are thoroughly cleaned and inspected, upon return to the plant, before reloading.

Barrett Anhydrous Ammonia is stocked in cylinders at points conveniently located from coast to coast. The advice and help of Barrett technical service men are available to you for the asking.

This interesting and helpful booklet is packed with useful information on Anhydrous Ammonia. You can obtain a copy without charge or obligation, by requesting it from the address below.

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ALLIED CHEMICAL & DYE CORPORATION
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- VARIABLE STOCK LENGTHS from 6" to 72"
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- FUEL COST— 24¢ per ton

HAGAN

Automatic Recirculating DRAW FURNACE

Greater production . . . lower fuel costs . . . maximum flexibility in rate of heating and length of soaking time—get *all* these in the Hagan Automatic Recirculating Draw Furnace.

This multi-zone furnace has separate heaters, fans and controls for each zone. Automatic temperature control, mechanized conveyor and Hagan forced convection heating all assure a uniform product through a wide range of part sizes and weights.

Check with Hagan for proved furnace dependability and economy.

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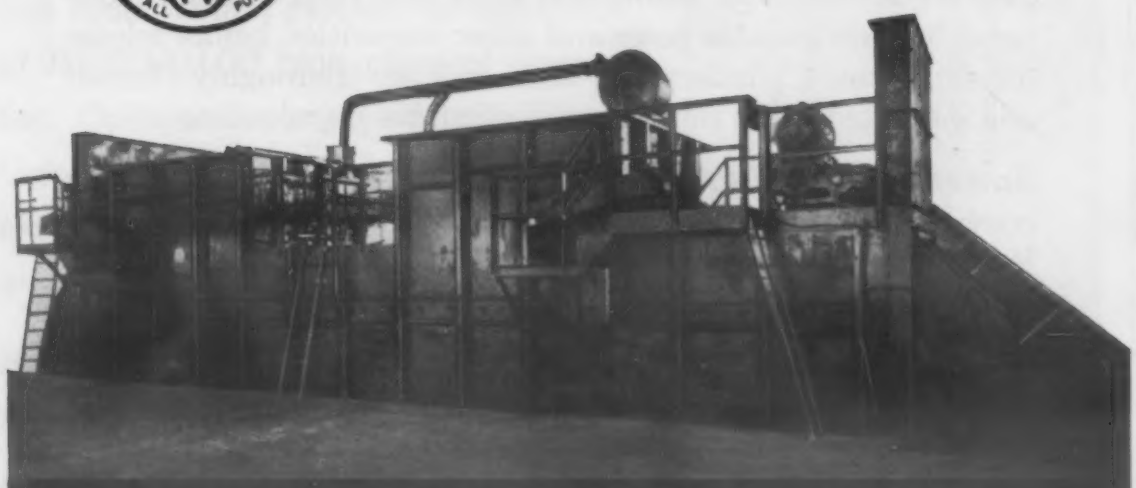


GEORGE J. HAGAN COMPANY

PITTSBURGH, PA.

Detroit . . . Los Angeles . . . Chicago . . . San Francisco

rod for sheet aluminum. The rod is good for use on very thin sections of aluminum. It melts at a temperature well below the melting point of sheet aluminum.

This rod has been especially developed for repairing aluminum coach bodies, manufacturing furniture and cooking utensils, and for other applications where its low melting temperature and economy in use are essential factors. It produces corrosion-resistant welds with a tensile strength of 30,000 psi. This new rod is known as All-State No. 31 sheet aluminum brazing rod.

New Process Reclaims Metals from Solution

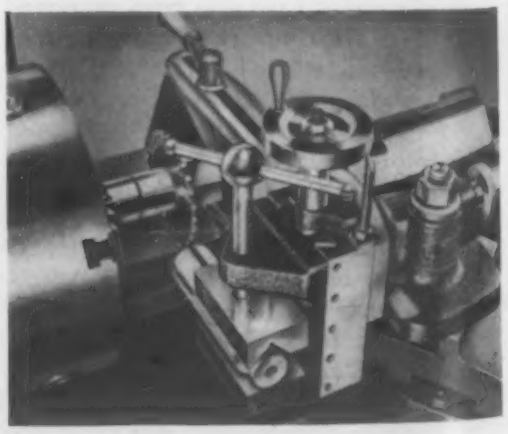
A new process especially for reclaiming silver from exhausted photo hypos, but which may also have application in reclaiming other valuable metals from solutions, has been patented by *Gopher Laboratory,* 19 Washington Ave., North, Minneapolis 1, Minn.

The principle of this new unit consists in pumping the liquid through a filter cartridge which collects the metal as the liquid passes through. The filter cartridge is 3½ in. in dia. and 34 in. long. This is connected to a pump, and the other end of the unit immersed in the liquid.

In the case of photographic fixing solutions, using a mechanical pump, about 20 min. is required to process 50 gal. of hypo. Recovery is said to be practically 100%.

Attachment Converts Lathe to Milling Machine

A new development in quick change lathe tools is the milling attachment offered by *Kyle-Johnson Machine Co.,* 1627 West Pico Blvd., Los Angeles 15, Calif. The new milling device can be mounted on any engine lathe, enabling the operator to perform any light milling job, such as milling keyways, flats and small shafts. It can also be used as a drilling vice.



This milling attachment can be used on a lathe for simple milling work, rather than setting up another machine.

The milling attachment is graduated in thousands and has a vertical travel of 6 in. The jaw opening is 2⅞ in. The attachment is flexible enough to permit angle milling, and may be tilted as desired by the operator.

Beach Grinder Features Small Diameter Motor

A new type of bench grinder, featuring a special-diameter motor, has been announced by *Bardco Mfg. & Sales Co.*, 2450 E. 23rd St., Los Angeles. An advantage claimed for this new design is the complete absence of any projection in the working area between the two grinding wheels, permitting the use of the grinding wheel much longer than has previously been possible. Because the diameter of the motor is approximately equal to the diameter of the retaining rings of the grinding wheel, the entire grit portion of the wheel can be utilized.

The grinder base and motor housing are cast aluminum, designed to shed dust and metal particles. Grinder speed is 3600 rpm.

Models with 7-, 8- or 10-in. wheels are now in production. Standard equipment furnished includes: two high-speed organic-bond wheels, one coarse, one medium; two enclosed wheel guards with adjustable tool rests and spark shields; built-in toggle switch.

● *The J. W. Kelley Co.*, 1044 Society for Savings Bldg., Cleveland, Ohio have developed in their new drawing compound a non-pigmented lubricant readily removed from any work piece to be enameled or bonderized, regardless of time elapsed between die work and finishing. It is applied by brush or dip, may be cut to proper consistency with water, and contains no mineral oils. A mild alkali cleaner, emulsified solvent or degreaser completely removes the compound.

Printing Machine Marks Steel Forms Continuously

A new marking device for printing continuous or spaced impressions on tool steel, sheet steel or steel tube has been developed by *Jas. H. Matthews & Co.*, 3909 Forbes St., Pittsburgh 13, applicable for marking of manufacturer's name, trademark, grade or specifications over entire lengths.

The unit consists of a cast aluminum frame with detachable cast handles which may be removed if the unit is to be mounted in a fixed position. Sets of adjustable rolls guide the unit during the marking operation. Interchangeable segment shaped rubber type and logotype dies are used, and a special device provides for quick changing of type in any quarter section of the printing wheel.

An adjustable blade in the ink fountain gives equal distribution of ink over the entire surface of the printing roll. The printing machine will print all sizes of flat and round bars from ¼-in. sq. or ¼-dia. up, flats or sheets ¼-in. wide and up. Separate machines are designed for round bars, for flats or squares, and for sheets and strips.

BRIGHT COPPER
PLATING PROCESS

Enables mirror-bright copper deposits to be obtained from a simple cyanide copper plating solution over a wide range of operating conditions

MAC DERMID Bright Copper PLATING PROCESS

METEX Number 15
BURNISHING COMPOUND

Burnishes Brass, Copper, Stainless Steel and Nickel Plate to a high degree of sparkling luster in 20 to 30 min. Eliminates the expense of steel burnishing balls.

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YOUR METAL FINISHING FOREMEN NEED THESE FOLDERS. WRITE TODAY TO DEPT. M.

MAC DERMID INCORPORATED specializes in formulating efficient and faster acting compounds to speed up production and increase profits. The folder on MAC DERMID *Bright Copper* Plating Process outlines fully the standard formula . . . operating conditions . . . type anodes used . . . equipment required.

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A 2000 pound Pressure-Tight High Alloy Casting Assembly

DURALOY
Statically Cast Return Bends

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DURASPUN
Centrifugally Cast Tubes

This is the "coil" of a special heat exchanger alloyed and cast for a large company in the Rocky Mountain area. It's an excellent example of the kind of work our metallurgists and foundrymen are capable of turning out.

Backed by 25 years' experience with high alloy static castings and 16 years with centrifugal castings, we are in a position to produce any chrome-iron or chrome-nickel casting within the range of our electric furnace capacity—namely, about 4 tons for any one pour. We have an X-ray testing machine. We can finish the casting to any degree desired.

Write us about your problem. Send us drawings for a quotation.

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4-DU-1

Attachment Controls Vibration in Processing Equipment

A simplified steel spring vibration isolating unit, designed in 26 sizes for rated loads of 75 to 12,000 lb., has been announced by the *Korfund Co., Inc.*, 48-05 32nd Place, Long Island City 1, N. Y. Adjustable resilient chocks in the four corners of the housing act as stabilizers.

This vibration controller is designed in 26 sizes for use on a variety of industrial equipment.

Properly installed and adjusted, it provides efficient vibration control for all impact machinery, generators, material testing and processing equipment, ventilating and air conditioning equipment, recording apparatus, business machines, and other industrial equipment.

Positioner Developed for Automatic Welding

A new positioner for users of automatic sheilded metallic arc welding has been announced by *Mark F. Gouran*, Welding Engineer, 7426 Devon St., Mt. Airy, Philadelphia.

This fixture is made up of an automatic shielded arc welding head, traveling on a beam that encompasses a vertical zone of 8 ft., with the assembly rotating around a fixed axis to a maximum radius of 20 ft. It is manufactured in three standard sizes, providing a 10-, 15- and 20-ft. horizontal arc travel.

The traveling asembly is the "Lincolnweld" head and carriage manufactured by the Lincoln Electric Co., Cleveland. The head travels on the beam to lengths, stated above, while the vertical operation of the head, powered by a motor-driven adjustment on the beam, covers an operating zone from the floor upwards to a height of 8 ft.

The vertical adjustment of the beam can be made at a rate of 36 in. per min., and permits inching the beam up or down to obtain the exact height for any particular welding operation. The beam, in its horizontal applications, may be swung manually 360 deg. about its axis, varying in radii according to the length of the beam. "Arc Positions" of larger capacities are designed and constructed on custom-built jobs only.

General Purpose Arc Welder Designed for Small Shops

A general purpose transformer arc welder, designed for use on single-phase power lines of limited capacity, is available from *Westinghouse Electric Corp.*, P. O. Box 868, Pittsburgh 30, in three output ratings—130, 160, and 180 amp. The three available models come complete with line breaker, power cable with plug and receptacle, insulated electrode holder, electrode lead with holder and adjustment plug, work lead with ground clamp and adjustment plug, electrodes, helmet, wire brush, and a welding instruction manual.

The welders have 20 steps of current adjustment between 20 amp. and the rated maximum. They provide two striking voltages: 65 volts for small electrodes on the lower half of the range; 50 volts for larger electrodes on the upper half of the range. There are Deion circuit breakers to control the flow of current to the welder and to give over-load and short-circuit protection.

Class B insulation is used throughout. Design provides adequate natural ventilation. No moving parts, which means a minimum of maintenance.

● A mechanism to reverse the polarity and to control a selected time cycle between the positive and negative plating times is announced by the *George L. Nankervis Co.*, 5442 Second Blvd., Detroit 2, Mich. The unit consists of a moisture proof cabinet, in which are mounted various instruments such as complete timer controls, relays, discharge resistors, pilot lights, etc., to control the output polarity of electroplating motor generator sets.

Spacing Table Handles I-Beams for Flange Punching

A new spacing table, designed to handle I-beams of varying weights and sizes for flange punching without any adjustment of the spacing table is in production at *Beatty Machine & Mfg. Co.*, Hammond, Ind.

This handling of I-beams by the new spacing table is accomplished by carrying the beam on the underside of the top flange, which, regardless of the size or weight of the I-beam, is always at die level and free to pass over the dies. Previously, I-beams were carried on the underside of the bottom flange, which called for adjusting the rolls to meet varying sizes of beams.

When a beam is to be placed on the table, the arm carrying the one set of rolls is opened by means of an air cylinder. When the beam is partially lowered, into the table, the arm is closed by air cylinder, and the beam is fully lowered until the underside of the upper flange rests on the roll. The spacing table carriage is arranged to grip the top flange of the beam for movement during the punching operation.

BOWSER ESTABLISHED 1885

Bowser speeds output, reduces damage and improves product quality.

EXPANSION FITTING

ELIMINATES HYDRAULIC ARBOR PRESS WORK TO SAVE FINISH & TOLERANCES IN CRITICAL ASSEMBLIES

. . . cuts inspection rejects in bushing, sleeve, valve, inserts, liners, seals, bearings, races, gears, pins, collars, shafts, etc., and eliminates reaming because super finishes are retained. Ordinary press fits require great pressures to obtain even 50% mating of parts. With Bowser expansion fitting, slight pressure attains excellent mating.

Bowser mechanical, direct expansion refrigeration attains −150° F. with fast B.T.U. removal at low cost.

In addition to expansion fitting, Bowser chilling machines are used for hardening cutting tools after heat treating to increase life between grinding.

. . . Connecticut Manufacturing plant uses Bowser unit for hardening critical parts and in difficult bushing assembly.

Available NOW! IN 5 AND 11 CUBIC FOOT Capacities

Up to 1500% more cuts between grinds when tools are Bowser cold treated!

A typical Bowser user formerly used an hydraulic press to insert a bushing. Now, with ½ hour chilling, the part is tapped into location. Formerly 2 hours were required with tolerance damage. Bowser expansion fitting takes 1½ minutes without damage and bushings hold better to the extent of 5 tons pressure differential for removal.

WRITE FOR COMPLETE INFORMATION

Complete catalog data sheets with machine specifications are available. Write for complete set today.

WHAT IS YOUR PROBLEM? BOWSER ENGINEERS MAY HAVE THE ANSWER

BOWSER, INC.

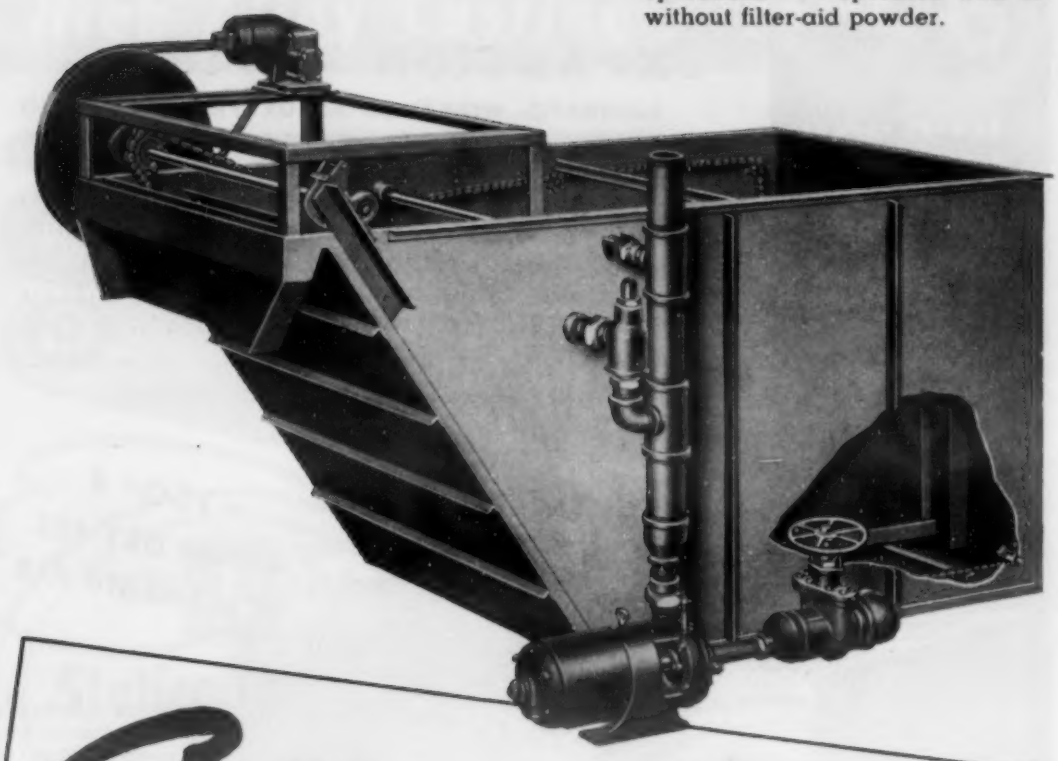
Gentlemen: ☐ Please rush complete set of catalog folders on industrial chilling machines.
☐ Have Bowser representative call on us.
(Bowser representatives are conveniently located in major cities.)

BOWSER ESTABLISHED 1885

MODELS FOR LABORATORY AND INDUSTRIAL USE

BOWSER, INC. • REFRIGERATION DIVISION • TERRYVILLE, CONN.

IN CANADA, S. F. BOWSER, LTD. • 183 GEORGE ST. • TORONTO, ONTARIO



Continuous, self-cleaning vacuum filters in a wide range of sizes. Especially designed for grinding operations . . . operated with or without filter-aid powder.

Save .. on production and maintenance costs with HOFFMAN FILTRATION

Production costs go down when Hoffman Filtration goes into your plant. Hoffman Filtration of wash oils, machine tool coolants and other industrial oils, lengthens life of machines, cutting tools and grinding wheels.

Hoffman Filtration practically eliminates pump trouble, bearing trouble and reduces wear and clogging on all moving parts on machine tool as well as in filter operation. Expert Hoffman filtration engineers are available to help you determine the filtration requirements for your particular operation and design special models if necessary.

Write for details today!

U. S. HOFFMAN MACHINERY CORPORATION
223 Lamson St., Syracuse, N. Y.
COOLANT FILTERS • FILTRATION ENGINEERING SERVICE

Double Vat Hot Dip Tanks Thermostatically Controlled

For hot dip operations two new groups of indirectly heated melting tanks have been developed by *Aeroil Products Co.*, West New York, N. J. The tanks are fully insulated and thermostatically controlled so that any temperature from 100 to 550 F can be held accurately.

The new tanks are built on the double boiler principle. They can be either gas-fired or electrically heated. Gas-fired units are heated from the inside by means of a patented immersion tube system. The electrically heated equipment is available in both 40-gal. size installations (equipped with heating elements of 13-kw. total capacity) and smaller portable 15-gal. capacity tanks.

The 40-gal. gas-fired unit has a dipping space 36 in. long, 17 in. wide, and 16½ in. deep. The overall tank dimensions are 5 in. long, 22 in. wide and 31 in. loading height.

A tank from one of the two new groups of melting tanks for hot dip operations is pictured here. These units, built on the double boiler principle, can be either gas fired or electrically heated.

The gas-fired units can use city, manufactured, or bottled gas. Maximum operating fuel consumption with the 40-gal. model is 24 cu. ft. per hr. of manufactured gas and 13 cu. ft. per hr. of natural gas.

● A new melting pot for aluminum, white metal, zinc, etc., has been announced by the *Kindt-Collins Co.*, 12651 Elmwood Ave., Cleveland 11, to meet the heavier demands which are being made on this type of equipment with the rapidly expanding use of these metals. This new melting pot has a 50-lb. capacity, and is normalized to prevent cracking. Use of 2-man bale permits pouring of metal from same pot in which it was melted. This minimizes agitation and reduces porosity.

New Line of Milling Machines Have Vibration Dampers

A line of new hydromatic milling machines with increased cutting capacity and higher spindle speeds for high-speed carbide milling has been announced by the *Cincinnati Milling Machine Co.*, Cincinnati 9. Like the superseded models, the new machines are of bed-type construction, with automatic table feed cycles, and infinitely variable hydraulic table feeds.

Standard machines are built in plain and duplex styles, and in twelve sizes, No. 3-24 (24-in. table traverse, 7½ h.p.) to No. 56-90 (90-in. table traverse, 30 h.p.)

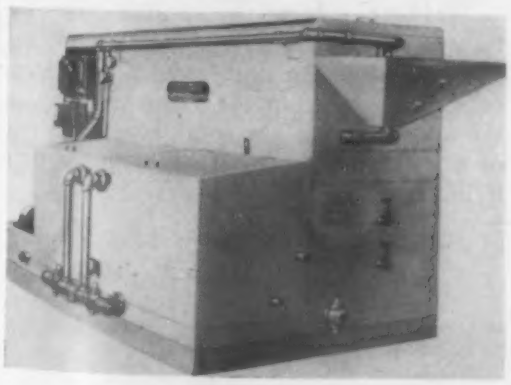
An innovation in design is the vibration damper construction of the overarm. This casting has a built-in unit which arrests vibration at the outboard end of the arbor, reducing the need for supplementary support through the arbor support braces.

A choice of seven ranges of spindle speeds are available. The highest group (cataloged as "3rd High") ranges from 164 to 1225 rpm. for small spindle carriers, 137 to 1000 rpm. for medium spindle carriers, and 110 to 820 rpm. for the large spindle carriers. Eight speeds are available within each range.

Screw-Drum Washer and Dryer Adaptable to Many Jobs

A new screw-drum type machine which can be used for washing and drying metal parts, rinsing and drying them, or any part of these operations, has been announced by *Optimus Equipment Co.*, 267 Church St., Matawan, N. J.

The new machine can also be adapted for a wash-drain, rinse-drain, cold or hot air dry sequence, or for pickling operations. It is particularly designed to handle difficult rinsing and drying jobs involving screw machine or small stamped parts.



This equipment washes, rinses and dries screw machine and stamped parts.

The dryer end is completely closed to avoid air loss. The air stream passes through a heater and blower which provides for either hot or cold air blast system. All parts of the machine are readily accessible for lubrication, maintenance or alterations. Centralized lubrication may be provided.

For

HOT FORGING
FORMING
COINING

THIS self-contained HYDROLECTRIC Forming Press can do a big job for Hot Die-Forging or Forming . . . and *do it well,* automatically.

The original 2,000-ton press of this model was designed for the forming of splice plates to size and shape from blanks, at a minimum production rate of five per minute.

Standard equipment contains a centralized control system providing for full automatic, semi-automatic or manual operation . . . just by setting the selector switch. Also available is a special die-setting control providing sensitive platen movement.

Outline your needs so that we may send descriptive literature, or the advice of our engineers. R. D. Wood Company, Public Ledger Bldg., Independence Square, Phila. 5, Pa.

HYDRAULIC PRESSES AND VALVES FOR EVERY PURPOSE • ACCUMULATORS • ALLIGATORS • INTENSIFIERS

R.D. Wood Company
EST. 1803

Cast and use special refractory shapes in less than 24 hours!

Cast your own special refractory shapes with quick hardening J-M Firecrete—right in your own plant—and, you'll have them in service in *one* day.

Firecrete mixes and pours as easily as concrete, hardens quickly with negligible spalling and shrinkage. Cast Firecrete in any shape you need—for furnace covers and bottoms, door linings, baffle tile, burner rings and other types of monolithic construction.

Firecrete is available in three types: STANDARD for temperatures up to 2400 F; H. T. for temperatures up to 2800 F; L. W. (light weight, low conductivity) for temperatures up to 2400 F.

Prompt Service from your J-M Distributor

You can get quick delivery of Firecrete from your authorized J-M Refractory Distributor. There are more than 300 strategically located Distributors who keep Firecrete in stock.

For further information about Firecrete write for folder RC-17A, Johns-Manville, Box 290, New York 16, N. Y.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville FIRECRETE
The Standard in Castables

● To protect against the hazard of explosion caused by flame failure in industrial oil burner installations, *Combustion Control Corp.*, 77 Broadway, Cambridge 42, Mass., has announced a new photoelectric flame failure safeguard. When the flame fails, fumes and gases accumulate and combine with air to form a dangerous highly explosive mixture within the combustion chamber. The flame failure safeguard is said to provide for complete protection against this danger. The photoelectric cell "sees" that the flame has failed and turns off the fuel supply and the burner.

Seam Welder Joins Strip Steel Coils

A double roll seam welder for high-speed joining of coils where an overlapping joint is not objectionable but where speed in linking coils of varying width is highly desirable has been designed by *Thomson Electric Welder Co.*, Lynn, Mass. For continuous processing, coils must be joined during the brief interval gained by running off slack from the paid-out end of the old roll.

Where considerable time is required for making the weld or adjusting for weld width, an arrangement such as a looping pit must be provided to accommodate the excessive slack. With this new welder, an electronic timing device automatically handles adjustment for varying width.

The welder consists of a pair of seam welding wheels mounted on a traveling carriage, each wheel powered by a 125 Kva transformer. The carriage is actuated by a 3-h.p. motor working through a solenoid clutch and worm.

The speed of travel across the work is constant, making welds of consistent size with no excessive heat at the starting point. The weld timer is controlled by a pair of photo-electric cells mounted on the carriage over Lumiline light sources located beneath the level of the work.

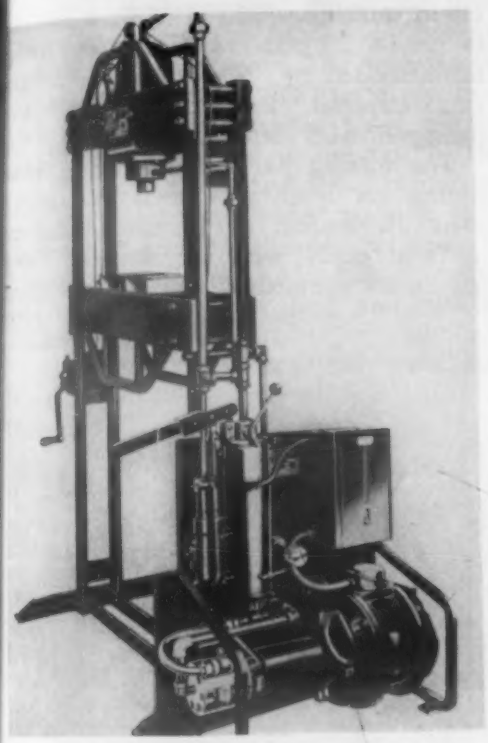
Welding current is applied when the light source is concealed by the work, and automatically cut off when the photo cells again pick up the beam on reaching the opposite side. The result is a double row of closely spaced spot welds with the rows 3 in. apart.

● A new torch attachment known as the Flash Circle Burner has been developed by *Scientific Research Co.*, 1618 W. Vancouver Ave., Dept. F-10, Portland 12, Ore., for cutting circles, curves or straight lines in plate. It is designed for rapid and simple height and radius adjustment; it can be used in any position—vertical or horizontal. It burns a minimum 2½-in. circle to a maximum of 17 in. An extension radius bar with adaptor is available to make possible circular cuts up to 10 ft. in dia.

New Line of Motor-Driven Hydraulic Arbor Presses

A full line of motor-driven hydraulic arbor presses—25, 50, 60 and 75-ton capacities—has been announced by *K. R. Wilson*, Buffalo, N. Y. These presses are designed as high production units in order to relieve heavier presses of short runs or small work.

The frame of the presses is made of hot rolled steel. Bed plates are trussed with all joints electrically welded. The bed is raised or lowered by means of a cable drum and crank. Since the frame is a weldment, most press dimensions may be changed to meet particular problems. Operation of the ram is controlled by a motor valve control. The motor-driven hydraulic pump used is a Seco radial type ranging in capacities from 5000 to 10,000 psi.



One of a new line of hydraulic arbor presses that are motor driven and of welded construction.

All units are equipped with a pressure by-pass valve, permitting required tonnage pressure to be accurately set and then maintained in successive operations. Another feature is the spring actuated, return ram which returns the ram to the "open" position instantly, when the control lever is released.

● The *D. C. Cooper Co.*, 1467 S. Michigan Ave., Chicago 5, has announced a new portable automatic steam cleaner. It cuts grease from auto chassis, motors, floors, walls, racks and equipment. It burns fuel oil or kerosene, and once the machine is set for the desired pressure it will operate automatically without attention until the operation is completed. Hourly fuel consumption is between 2 or 3 gallons of oil.

"we proved our ability to be of service . . ."

says W. H. Hulster
STUART OIL COMPANY
REPRESENTATIVE

Stuart Oil Performance Report on ThredKut 61

Type of product manufactured by company covered in this report:
Machined parts from rough forgings

Personnel interviewed:
Machine Shop Supt. and General Foreman

Stuart Oil Products used in this plant:
ThredKut 61, Solvol

Specific operations covered by this report:
Drilling and boring forged "5060" steel pump liners

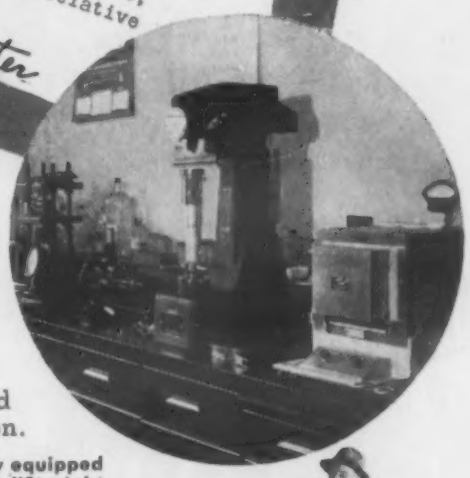
Performance details:
"Problem was presented here in boring 7½" dia. holes through 11" dia. x 30½" solid forged pump liners running about 170 Br. Liners are run on two heavy duty lathes, one starting with a 1" dia. drill followed with a boring bar; the other a heavy boring bar used for removing entire 7½" of stock.

"Solvol was performing well on 4615 steel, but when 5060 steel was substituted, they could barely get 1 to 1½ liners per day, from one lathe. Switching to ThredKut, tool life improved, but still only got one liner per tool grind, plus terrific vibration.

"Then they called us in on the trouble. Our inspection of tools indicated dilution was in order. A 6-1 blend of ThredKut and Pffe. was decided upon...and it licked the job...they now turn out 3½ liners per day per lathe, meeting production schedules...and are very appreciative of our help in solving this problem."

W. H. Hulster

HERE is another case where Stuart engineering service played an important part in solving a tough cutting problem. No "panacea" for all metal-working ills, Stuart Oil products must be used correctly to meet specific requirements. In this instance, the *right* oil was being used, but without necessary dilution. Our background and experience in helping to solve scores of similar problems is available to assist *you* in analyzing cutting fluid requirements. Write for further information.



Illustrated is one section of the completely equipped Stuart Metallurgical Laboratory, where the "Straight Line to Metal-Working Efficiency" begins.

D. A. Stuart Oil Co. LIMITED
EST. 1865
2745 SOUTH TROY STREET, CHICAGO 23, ILL.

STUART *service goes with every barrel*

Require a Vacuum Tight Joint Between Glass and Metal Tubing?

● **Cerroseal-35 will do the job quickly and permit taking apart easily.**

The procedure: tin inside of metal tubing to depth of joint, using any flux. Wash off all flux. Tin outside of glass tubing by wiping molten alloy on tubing, which has been warmed to alloy's melting point, about 244° F. Warm both parts to be joined to give an appearance of wetness and insert glass tube into metal tube. Flow excess alloy into joint to completely fill space and allow to cool. Recommended alloy film thickness — .002" to .004".

Cerroseal-35 is one of a series of interesting and useful Indium alloys having very low melting temperatures.

They are:	*Melting Temperature*
Cerrolow-105	* 105°F
" -117	117°F
" -136	136°F
" -147	* 147°F
" -174	174°F

	Melting Temperature
Cerroseal- 35	* 244°F
" - 25	* 294°F

** Non-eutectic alloys—yield temperatures are those given.*

Suggested and actual uses: Fusible links in automatic fire alarm and extinguisher devices; in manual reset thermal switches for controlling processing; or for signalling rise of temperature, as in bearings; thermal safety controls in refrigeration, diathermy and electronic equipment. As a proof casting medium for delicate machine work, Cerrolow-117 can be poured without fear of over expanding metal parts and shrinks but .0002" per inch after casting.

Delicate soldering in small instruments will not be disturbed if dial covers are sealed with one of these low temperature melting alloys.

Describe your problem. Perhaps we can help.

CERRO DE PASCO COPPER CORPORATION

DEPT. 8 · 40 WALL STREET · NEW YORK 5, NEW YORK

Makers of Cerrobase, Cerrobend, Cerromatrix, Cerrosafe and Cerrotru.

Master Hands on Intricate Jobs use

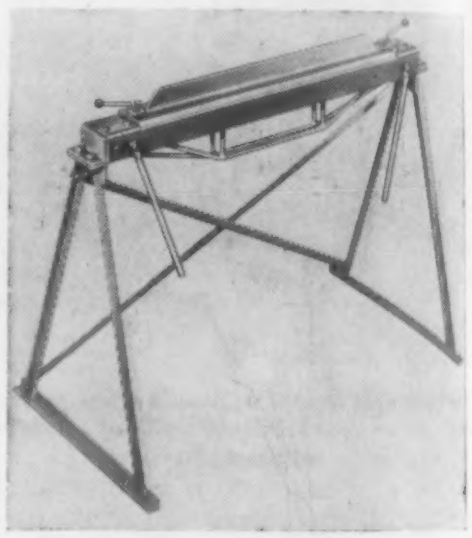
SHAWINIGAN CARBIDE

● The gas generating unit produced by *Vapofier Corp.*, 10316 S. Throop St., Chicago 43, is now being used as a means of firing atmosphere producers, which are used in connection with electric furnace equipment. The unit, utilizing fuel oil, generates the gas, which is burned in the combustion chamber of the atmosphere producing equipment. The resulting products of combustion are then taken through condensers which remove the water vapor, and the resulting atmosphere is delivered to the furnace or oven under any desired pressure.

Portable Sheet Metal Brake Bends 20-Gage Material

A new portable sheet metal brake, available in working widths of 31 in. and 49 in., to handle 20-gage material, is now being manufactured by *Webb Machine & Tool Co.*, Imperial, Pa. Both models come equipped with detachable stand.

The folding bar is controlled by cams resting on leveling washers that permit even distribution of pressure. Cams are operated easily with the fingers; folding bar raises automatically when pressure is relieved, and can be completely removed for bends that cannot be made with fixed bars.



This bending brake bends up to 150 deg. and is available in two models.

Bends up to 150 deg., including the "Pittsburgh" bend, can be made. Pan boxes up to 1-¾ in. can also be produced, without any special adjustment.

● For applications of temperature measurement, the *Foxboro Co.*, Foxboro, Mass., is manufacturing a line of instruments, known as Dynalog, available with ranges between –200 F and 2800 F, and for use with thermocouples or electric resistance bulbs. In addition to temperature applications, they are also in use for the measurement or control of humidity, force, strain, pH, speed, and many other process variables.

Electric Soldering Tool Requires No Preheating

A new model of their standard soldering tool is being manufactured by *Ideal Industries, Inc.*, 1928 Park Ave., Sycamore, Ill. Operating on the resistance heating principle, the new unit is said to heat 20% faster, has thumb switch for close heat control, is light-weight, portable, and can be used for long periods of time without overheating.

The complete unit includes a transformer or power unit and a soldering tool that operates like a pair of pliers. Holding the work with the tool completes the transformer secondary circuit and causes the work to heat. No preheating is necessary. Heat is produced between the electrodes of the soldering tool only.

Handles of the soldering tool are made of plastic. Radiating fins isolate the meehanite jaws from the handles to prevent excessive heat conduction. The tool can be locked in any position for special applications by tightening screw at hinge. Secondary leads are attached to the side of the jaw for easy handling and cooler operation. The tool is intended where work be held in the jaws and heated—for example, in removing or applying solder lugs, sweating and unsweating copper pipe and fittings, soldering wire joints, etc.

The unit is rated at 1000 watts and measures 10¾ in. by 8 in. by 10⅜ in. overall.

Portable Induction Heater for Weld Treatment

A new portable induction heater manufactured in units of 10 Kva. for preheating and normalizing for welding has been announced by *Electric Arc, Inc.*, 22 Jelliff Ave., Newark 8, N. J.

The heater was developed primarily for its flexibility and adaptability to a wide range of applications and capacities, thus eliminating the necessity of stocking a number of heaters in several capacities to handle large and small work. The individual units of 10 Kva. each may be stacked on the job to form groups of 2 and 3 units with capacities of 20 and 30 Kva., to obtain sufficient heater capacity for preheating and normalizing welded joints on pipes of larger diameters. The 30-Kva. group, for instance, is capable of preheating a 10-in. pipe joint to 1300 F in 2 hr.

The heater is useful in a limited space and crowded conditions, and can be kept close to the work. The unit is complete in itself containing power unit, contactor, meters and control supply. Heating current and voltage output variations are brought about by a selector switch built into the unit. Controlling pyrometers and program controllers can be plugged into the induction heater in two polarized receptacles for recording job temperatures and heat cycles. Polarized receptacles are also provided for the inter-connection of the heater into groups and for the power supply to the units.

This practical test for
SURFACE WEAR RESISTANCE
...provides the facts in minutes

The TABER ABRASER is easy to operate

. . . gives a permanent, accurate rating

Duplicating—in measurable terms—the rubbing abrasion encountered in actual service, the Taber *Abraser* enables you to determine in advance the inherent surface wearability of paints, lacquers, plating, textile, leather, rubber, metals and many other materials. Saves time required for wear performance tests—gives a permanent, accurate value rating for research studies as well as for production control.

YOURS on request — Manual explaining fully the Taber Method and the reasons why it pays to pre-test. (Also included—brochure on stiffness and resilience testing with the Taber V-5 Stiffness Gauge.)

TABER INSTRUMENT CORP.
109 Goundry St., North Tonawanda, N.Y.

The Taber Test *Proves* What Wears Best!

HOW THE WROUGHT BRASS INDUSTRY CONSERVES METAL

No industry melting *commensurate tonnage of vital metal can quite match the brass mills for conservation and low melting losses. The savings of metal total millions of pounds; clearly the method they use is worth noting:**

Virtually all the brass mills in North America use the Ajax-Wyatt induction melting furnace, for it has the lowest metal losses in the field — less than 1% — with superior temperature control and unapproached economy of operation on high production schedules such as we have today.

The accepted melting tool in brass rolling mills throughout the world.

AJAX ELECTRIC FURNACE CORP.
1108 Frankford Avenue
PHILADELPHIA 25, PA.

* UPWARDS OF 5 BILLION POUNDS ANNUALLY

THE AJAX WYATT INDUCTION MELTING FURNACE

ASSOCIATE COMPANIES:
AJAX METAL COMPANY, *Non-Ferrous Ingot Metals and Alloys for Foundry Use*
AJAX ELECTROTHERMIC CORPORATION, *Ajax-Northrup High Frequency Induction Furnaces*
AJAX ELECTRIC COMPANY, INC., *The Ajax-Hultgren Electric Salt Bath Furnace*
AJAX ENGINEERING CORPORATION, *Ajax-Tama-Wyatt Aluminum Melting Induction Furnaces*

Research Pays Off

ANNEALING silica ware is only one step in Amersil's research program designed to produce silica and quartz ware that lasts longer on the job.

Amersil now offers an engineering service which includes development, research, design, controlled manufacture of major silica ware units, selection and purchase of auxiliaries—all under one contract—one responsibility.

If you have a problem involving extreme temperatures and highly corrosive operating conditions—get in touch with an AMERSIL engineer.

LASTS *a minimum of* 10 TIMES LONGER

Unsolicited advice from a consistent user* of AMERSIL ANNEALED SILICA TRAYS states they last a minimum of ten times longer than trays which have not been annealed.

*Name on request.

AMERSIL COMPANY Inc.

ENGELHARD

CHESTNUT AVENUE HILLSIDE 5, N. J.

Johnson Steel Spring Wire (XLO Music Wire) is available in a wide range of sizes from .003" (38,206 ft. to the lb.) up to .200" (9 ft. to the lb.). Produced with micrometer precision, this wire of a thousand uses — springs, wire forms, appliances—is available from Johnson sales offices.

JOHNSON

STEEL AND WIRE COMPANY, INC.

WORCESTER 1, MASS.

NEW YORK AKRON DETROIT CHICAGO LOS ANGELES TORONTO

News of...

ENGINEERS COMPANIES SOCIETIES

Engineers

Dr. William A. Mudge has been appointed director, technical service section, Development & Research Div., International Nickel Co., Inc. and *William F. Burchfield,* assistant director. Dr. Mudge succeeds *O. B. J. Fraser* who became assistant manager of that division. Mr. Fraser succeeds *H. J. French* who became vice president. Dr. Mudge joined International in 1920 and is prominent in technical society activities. Mr. Burchfield has been with International since 1925 and is a prominent technical society committeeman. *Donald J. Reese* takes on added duties in charge of field sections. *H. J. Fraser* has been made a vice president.

William D. Taylor, engineer of tests, Lukens Steel Co., is now assistant metallurgical engineer, while *Samuel D. Lemmon,* assistant engineer of tests, becomes engineer of tests. Mr. Taylor was graduated from Swarthmore College in 1936; Mr. Lemmon, from Pennsylvania State College in 1939.

Dr. Daniel S. Eppelsheimer has been made associate professor of metallurgical engineering at the Missouri School of Mines and Metallurgy, Rolla, Mo. He will teach and research in ferrous metallurgy and X-ray examination of metals. He was formerly chief physical metallurgist and sales manager of Metal Hydrides Co.

William Kerber has been appointed vice president and general manager, Hanna Furnace Corp. He was once deputy assistant director, WPB's Steel Div. and later assistant to the president, Hanna Furnace Corp.

Dr. Alfred J. Reis, Austrian-born and one of the world's leading experts on X-ray diffraction, has been made research specialist in the Engineering Experiment station at Rutgers University, New Brunswick, N. J. He will conduct studies in the engineering properties of materials and in powder metallurgy. Previous studies have embraced metallurgy, catalytic gas reactions, crystal structure and X-ray diffraction, spectrographic analysis, pigment colors, materials testing, appli-

News of...

ENGINEERS COMPANIES SOCIETIES

cations of ultrasonics in chemistry and metallurgy, and the chemistry and spectroscopy of flames.

A. C. Meyers has been made manager, nickel department, Williams & Co., Pittsburgh, which distributes nickel for the International Nickel Co. For 20 years he has helped develop the use of nickel in castings.

Dr. C. D. D'Amico has become manager, special steels department, Los Angeles plant, Joseph T. Ryerson & Son, Inc. He secured his Ph.D. degree in metallurgy from the University of Michigan in 1939, and has served as plant metallurgist, Rich Mfg. Co., Battle Creek, Mich.

George S. Evans has retired as metallurgist in charge of fused alkali products for the metals trade, with the Mathieson Alkali Works, to continue with the company as a consultant. He joined the company as a metallurgist in 1925 and has been granted many patents involving railroad equipment, metal testing apparatus, cupola furnace equipment and processes; also use of alkalis in metallurgy. He is author of many technical articles and is a technical society member.

Dr. W. L. McCracken has become director of research and manager of alkali manufacturing by Detrex Corp., Detroit, his activities covering both industrial metal cleaning and dry-cleaning divisions. He holds three degrees and is a member of two chemical societies.

Arthur McCutchan has been appointed senior research engineer, product engineering and research department, Tube Turns, Inc., Louisville, Ky. He is author of numerous articles on piping.

Harold M. Patterson, for three years manager, Taunton Works, General Electric Co., Plastic Div., has been made engineering manager, that division, being succeeded by *Frank Gimblette,* mechanical engineer, Plastics Div. Mr. Patterson joined G.E. in 1929 as a product engineer.

Dr. William Marshall Nelson has joined Traubee Products, Inc., Brooklyn, N. Y., as metallurgist, having received his doctorate in metallurgy at Columbia University. Recent affiliations have been with Brewster Aeronautical Co. and Reynolds Metals Co.

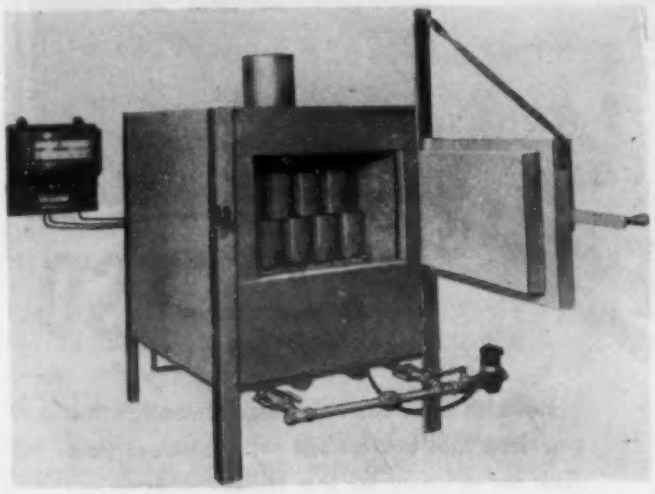
John L. Abbott recently joined

SAUNDERS GAS FIRED OVENS

THREE SIZES AVAILABLE

Wax Elimination—Tool Hardening

Temperatures to 1800°F without blower



SAUNDERS #3W OVEN

Heavily insulated, angle iron frame gas fired BUZZER Atmospheric burner

Inside working dimensions: 18" x 18" x 12" high
Overall dimensions: 30" wide x 38" deep x 46" high

Developed to meet the needs of the precision casting industry, these ovens can be used for work requiring open flame annealing temperatures up to 1800°F

•

With Brown Single point indicating pyrometer controller and stand, crated
F.O.B., New York $507.50

•

With Indicating Pyrometer and stand, crated
F.O.B., New York $345.00

•

These ovens are an important piece of equipment for precision investment casting. For related equipment write:

ALEXANDER SAUNDERS & CO.

Succ. to J. Goebel & Co.—Est. 1865

Precision Casting Equipment and Supplies

95 BEDFORD STREET **NEW YORK 14, N. Y.**

Roll-Away Covers

SAVE ELECTRIC POWER

A ball-bearing roll-away cover saves from 20% to 50% electrical power input—an exclusive feature designed and built into every Dempsey Immersed Electrode Furnace.
Heat treaters really like this feature. Cover rolls back with practically finger-tip effort—giving better and more comfortable working conditions. Another example of designing by Dempsey Engineers that makes for greater efficiency and economy in all Dempsey Heat-Treating installations.
Send us your Heat-Treating problems—there's a Dempsey representative near you—wire, write or phone—no obligation.

Write Dept. 2

FURNACES: Oil-Gas-Electric-"TAILORED" by DEMPSEY
Meet every Heat Treating Need

DEMPSEY FURNACE

DEMPSEY INDUSTRIAL FURNACE CORP.

Springfield 1, Mass.

Cleaning baths made up with Metso insure chemically clean surfaces to take flash plating that sticks tight. Here's why —Metso crystalline silicates* contain the properly balanced combination of alkali-silica. No excess alkali or silica to attack the casting or leave a deposit.

FOR DIE CASTING PLATING THAT HOLDS....

BE SURE WITH metso

Results of recent careful investigation proving this statement will interest you. Ask for a copy of the report describing the tests.

* Sodium Metasilicate U. S. Pat. 1898707.
Sodium Sesquisilicate U. S. Pats. 1948730, 2145749.

PHILADELPHIA QUARTZ CO.
Dept. C, 125 S. Third St., Phila. 6

metso *Cleaners*

It's Here!
The FINELT
WAX INJECTOR

. . . acclaimed as the finest machine of its kind. A versatile, precision-made unit, ideally adapted to wax injection into both rubber *and* metal molds . . . can be used as either a hydraulic or air-pressure operated unit.

WATCH FOR THE FINELT MOLD KIT *coming soon!*

Check these features against any other wax injector on the market:

- Hydraulic or air-pressure operation
- Positive temperature control to within two degrees
- Positive pressure control to a fraction of a pound
- Complete control over the quantity of wax injected
- Complete visibility of temperature and pressure at all times
- Full two-quart capacity
- Designed for rapid wax pattern production
- Designed for simple fool-proof operation
- Available for operation on any type of electric current

Write for complete catalog

I.SHOR 64 W. 48th ST. • NEW YORK 19 • DEPT. M

precision casting sales and engineering

News of...

ENGINEERS COMPANIES SOCIETIES

North American Philips Co., Inc., as application engineer in the Industrial X-ray Div. He was employed by Wright Aeronautical Corp. from 1941 to 1946 as senior metallurgist.

Ralph E. Gordinier has been made chief research and design engineer, Eco Engineering Co., Newark 1, maker of gearless pumps. He has served as mechanical engineer and machine designer with the Buick and Ford motor companies.

Roy Farquharson has become assistant chief engineer, Pioneer Engineering & Mfg. Co., Detroit. He has had over 20 years' experience designing tools, dies and fixtures.

John Baldwin has been made assistant chief engineer, Weatherhead Co., Cleveland, directing project engineering, drafting and design. *B. R. Teree* has been made laboratory director.

Companies

The *Crucible Steel Co. of America* is launching a two-year program of plant expansion costing $30,000,000. New mills for large scale production of stainless steel sheets and strips are being installed; also expanded production facilities for bars, rods and special shapes.

The *Babcock & Wilcox Co.* also has a two-year program, involving $1,500,000 for machinery replacement and improvement at its plant at Barberton, Ohio. All types of shop equipment and machine tools will be purchased, not only to increase plant capacity but to improve quality of products.

William L. Batt, president, *SKF Industries, Inc.*, ended six and a half years of service in the Federal Government on Feb. 12 when his resignation as chairman of the Inter-Agency Committee on Rubber was accepted by the White House. He had previously been awarded the Medal for Merit by President Truman.

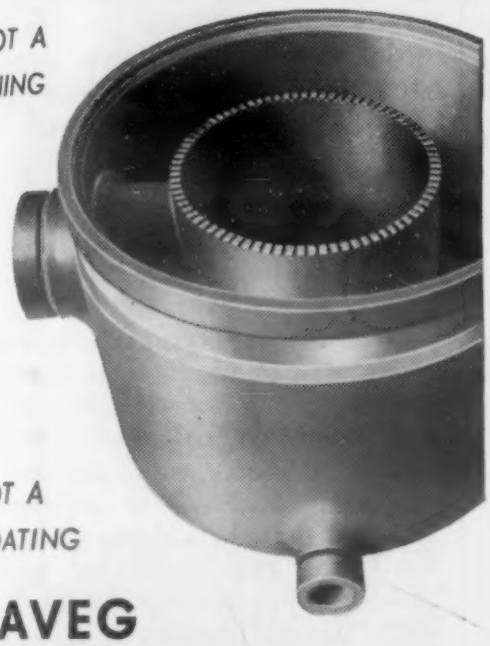
Westinghouse Electric Corp. will take over operation of the Sunnyvale, Calif., plant of the *Joshua Hendy Iron Works* under a lease arrangement. Organized in 1856 as a metal fabricating concern, Joshua Hendy employed 9,000 at its wartime peak. Hendy will continue operations at its plants at Torrance, Calif., and Ampere, N. J.

Non-Ferrous Foundries, Inc., 22nd &

PROCESS EQUIPMENT BY HAVEG

IS NON-CORROSIVE Through and Through

NOT A LINING



NOT A COATING

HAVEG is a solid structural material

It is a molded plastic, resistant throughout its entire mass to practically all acids, bases and salts; to chlorine, many solvents and other chemicals except those of a highly oxidizing nature.

HAVEG equipment is molded in light, inexpensive molds into many strong, durable shapes with seamless, solid walls. Tanks, for instance, are molded in one piece 10′ in diameter and 12′ high.

No process equipment buyer or user should be without complete information on HAVEG equipment. Send for Bulletin F-4.

HA-1-47

HAVEG CORPORATION
NEWARK 25, DELAWARE

CLEVELAND CHICAGO DETROIT LOS ANGELES

News of...

ENGINEERS COMPANIES SOCIETIES

Sherman Drive, Indianapolis, has installed facilities for production of special heat treatable copper alloy castings under license from *P. R. Mallory Co., Inc.* Such castings are appropriate for electrical and resistance welding applications.

Magnolia Metal Co., 18 W. Jersey St., Elizabeth, N. J., has acquired the *Evans Engineering Co.,* Waukesha, Wis., producer of a sleeve bearing in which the lining, or bearing metal, is permanently "fusion bonded" to the shell. Under the new arrangement Magnolia supplies the metal, with Evans fabricating.

The *Berger Mfg. Div.,* No. 2 plant, *Republic Steel Corp.,* Canton, Ohio, has virtually completed an extensive reconversion program, from sheet metal aircraft parts in wartime to steel kitchen cabinets. Because of steel shortage, production is at 50% capacity.

Research fellowships totaling $20,500 have been awarded to 14 graduate students by the *General Electric* Educational Fund. Awards are granted annually to graduates of colleges and technical schools who show promise.

One of the largest orders for universal testing machines ever placed with any U. S. company is now being delivered by the *Baldwin Locomotive Works* to the *Pittsburgh Testing Laboratory.* The six machines are of the Baldwin-Tate-Emery type for tension and compression tests on various materials.

The *A. R. D. Corp.* has removed engineering offices and laboratory to enlarged quarters at 157 Chambers St., New York 7.

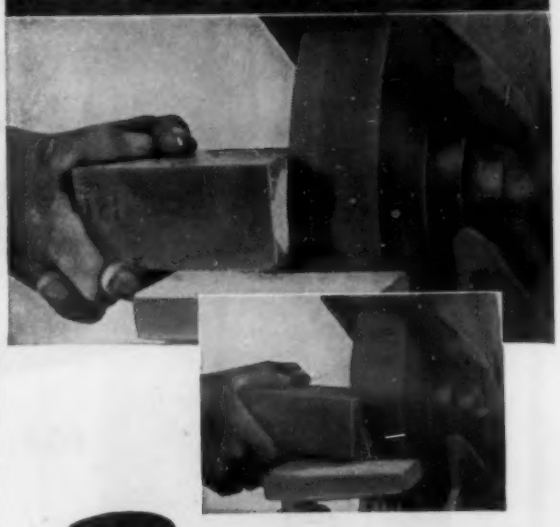
Leo N. Rich, Inc., industrial consultants, have opened offices at 1 Wall St., New York, to correlate economic and marketing research, industrial design and public relations.

The *Kimble Glass Co.,* recently acquired subsidiary of *Owens-Illinois Glass Co.,* will hereafter be known as the *Kimble Glass Div., Owens-Illinois Glass Co.,* with general offices at Vineland, N. J.

Allegheny Ludlum Steel Corp. is making a complete survey of its gas-fueled equipment to convert to oil to prevent future shut-downs from gas shortages.

Bradley Paint Engineers, Inc., Jones Law Bldg., Pittsburgh, is a new concern

BRICKSEAL
REFRACTORY COATING

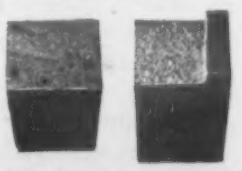


Resists
ABRASION

PROTECTION against abrasion is an outstanding advantage of Brickseal. Here are two refractory bricks, one coated with Brickseal, the other uncoated. They were heated to more than 2000°, taken directly from the furnace, cooled and shoved against an emery wheel. Hot and cold, the Brickseal-treated brick resisted the abrasion – see below.

Brickseal consists of high fusion clays and metal oxides combined in oil. Furnace heat burns away the oils and vitrifies the clays and metals which penetrate deeply into the pores, cracks and joints. Brickseal prevents cracking, spalling and slagging regardless of sudden temperature changes. Brickseal is also a mortar for laying up refractory walls.

Compare the Brickseal-treated brick at the left to the untreated at the right.



TRY IT YOURSELF on your emery wheel

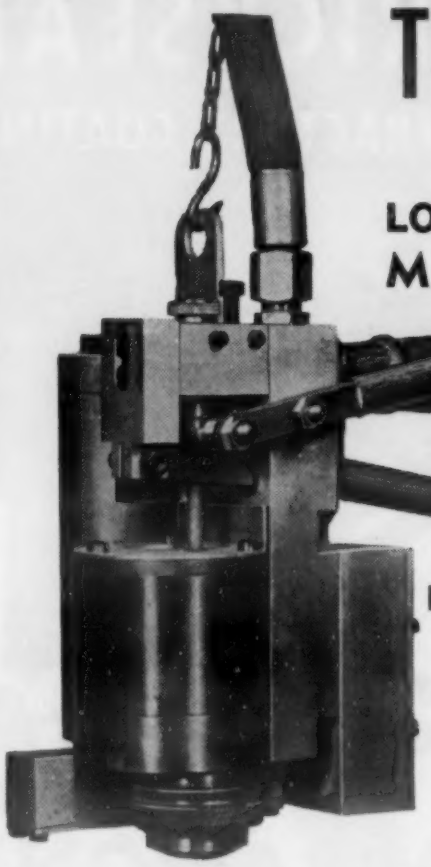
Two bricks bonded together and partially coated with Brickseal will be mailed to you on request.

BRICKSEAL
REFRACTORY COATING
5800 So. Hoover St., Los Angeles, Calif.
1029 Clinton St., Hoboken, New Jersey

This SPRAY GUN

melts and sprays

LOW MELTING TEMPERATURE METALS AND ALLOYS



The Fiore Alloy Sprayer handles a wide range of alloys and metals that melt at 100° to 600° F. Precision control of spray over wide range. Infinite detail can be reproduced.

FOR: Reproducing Parts
Producing Molds for Electro Forming
Producing Molds (for Lost Wax Process)
Making Dies
Also Used For:
Coating Wood Patterns
Spraying Selenium Rectifier Cells
And Many Other Uses

Long, maintenance-free production service one of the many features.

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News of...

ENGINEERS COMPANIES SOCIETIES

that will specialize in "paint engineering," combining chemistry and mechanical engineering to develop special coatings for industry and equipment to apply it.

The *Freeport Sulphur Co.* has acquired assets of the estate of the late U. C. Tainton, metallurgist and inventor, among whose inventions were processes for production of electrolytic zinc, electro-galvanizing steel products and metal cleaning processes.

The Toledo plant of *E. W. Bliss Co.* has undergone extensive re-equipping for manufacturing medium and large power presses. Included are a new cupola and blower arrangement, time and temperature controls, and testing equipment to produce Meehanite iron.

Societies

Max Kuniansky, vice president-general manager, Lynchburg Foundry Co., has been nominated for president *American Foundrymen's Assn.* in 1947-48, to succeed Sheldon V. Wood, whose term expires in July. William E. Wallis, president, Pittsburgh Lectromelt Furnace Corp., is named for vice president. The 51st annual convention will be held in Detroit, April 28 to May 1. The aluminum and magnesium division research committee will sponsor a fundamental study of the hydraulics of metal flow in a mold, with the idea of establishing proper size and shape of sprues, gates and runners for non-turbulent flow.

George N. Sieger, president, S-M-S Corp., Detroit, has been made president, *Resistance Welders Mfgrs. Assn.*, having been active in publicity and promotional work for the association.

Dr. Anderson W. Ralston, whose work at the Armour Research Laboratories, Chicago, resulted in extending the nation's failing iron ore supplies for at least 150 years, is named the winner of the 1947 Midwest Award, St. Louis section, *American Chemical Society.*

Raymond L. Collier has been appointed executive secretary, *Gray Iron Founders' Society, Inc.*, Cleveland, as of March 1. He formerly occupied a similar position with the *Steel Founders' Society of America*, with which society he was identified for over 18 years.

The *Broaching Tool Institute*, 74

News of...

ENGINEERS COMPANIES SOCIETIES

Trinity Place, New York 6, offers three 16-mm. motion picture sound films to those interested for public showings. The titles of the films are: "Broaching an Internal Keyway," "Single Ram Vertical Surface Broaching" and "Double Ram Vertical Surface Broaching."

Under auspices of the *British Engineers' Assn.*, an engineering and marine exhibition will be held in London's largest exhibition building, Olympia, Aug. 28 to Sept. 13, being the first of the series since 1937. The society is the national association of the principal engineering manufacturers in Great Britain, and was founded in 1912.

The *Association des Ingenieurs* (Engineers) of Belgium will celebrate its centenary at Liege, Aug. 30 to Sept. 13. The congress and exposition will be divided into 14 sections, including metallurgy, mechanics, electricity, chemistry and civil engineering.

Steps are being taken to unify and eliminate duplication of effort between the *Society of the Plastics Industry, Inc.* and the *Society of Plastics Engineers*. The matter is in a status of live planning.

The *Thomas Alva Edison Foundation* has been newly incorporated "to keep alive and active the genius exemplified in the life, accomplishments and ideals" of Edison. The planners hope to raise $2,590,000 to carry out a three-fold objective. Henry Ford will serve as honorary chairman of the group of industrialists, scientists and educators sponsoring the foundation. Harvey S. Firestone, Jr. is national chairman of a fund-raising project.

The motion of atoms in metals will be studied at *Stevens Institute of Technology* under sponsorship of Naval Research. The purpose is to understand better crystallization under vibration, or "work hardening." Radioactive tracers will follow the motion of the atoms. Stevens will also study metal powder techniques, sponsored by the Office of Technical Services, Department of Commerce. Particle size, sintering methods, chemical composition, density and other factors will be probed.

For the year beginning in the summer or fall of 1947, *Battelle Memorial Institute*, Columbus 1, Ohio, will appoint a few predoctoral fellows and postdoctoral associates to conduct fundamental investigations. Fellows receive a stipend of $1200 a year.

The *American Standards Assn.* has elected the following six directors: R. L. Pearson, New Haven Railroad; Curtis W. Pierce, National Fire Protection Assn.; J. H. Hunt, General Motors Corp.; J. H. McElhinney, Wheeling Steel Corp.; R. Oakley Kennedy, formerly of Cluett, Peabody; and Auguste G. Pratt, Babcock & Wilcox Co.

President Truman has called a national conference on fire prevention to meet in Washington May 6 to 8 in view of the average annual toll of 10,000 deaths from fire and a property loss of over $560,000,000 in 1946. Conference headquarters are at Room 7006, Federal Works Bldg., Washington 25.

The *Diesel Engine Mfgrs. Assn.*, 1 N. La Salle St., Chicago 2, is arranging an intensive, one-week educational conference for college professors who teach Diesel Engineering during the week of June 23 at the Hotel La Salle, Chicago.

Meetings and Expositions

SOUTHERN MACHINERY & METALS EXPOSITION. Atlanta, Ga. April 14-17, 1947.

OPEN HEARTH, COKE OVEN, BLAST FURNACE AND RAW MATERIALS CONFERENCE. Cincinnati, Ohio. April 21-23, 1947.

AMERICAN ZINC INSTITUTE, annual meeting. St. Louis, Mo. April 28-29, 1947.

AMERICAN FOUNDRYMEN'S ASSOCIATION, national convention. Detroit, Mich. April 29-May 2, 1947.

NATIONAL PLASTICS EXPOSITION. Chicago, Ill. May 6-10, 1947.

SOCIETY OF THE PLASTICS INDUSTRY, annual meeting. Chicago, Ill. May 6-10, 1947.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, annual meeting, Chicago, Ill. May 15-17, 1947.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Oil and Gas Power Division meeting. Cleveland, Ohio. May 21-24, 1947.

MID-AMERICAN EXPOSITION. Cleveland, Ohio. May 22-31, 1947.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Metals Technology Regional Conference, Boston, Mass. May 23-24, 1947.

INSTITUTE OF THE AERONAUTICAL SCIENCES, spring meeting. Detroit, Mich. May 26-27, 1947.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, aviation division meeting. Los Angeles, Calif. May 26-29, 1947.

METAL POWDER ASSOCIATION, spring meeting. New York, N. Y. May 27, 1947.

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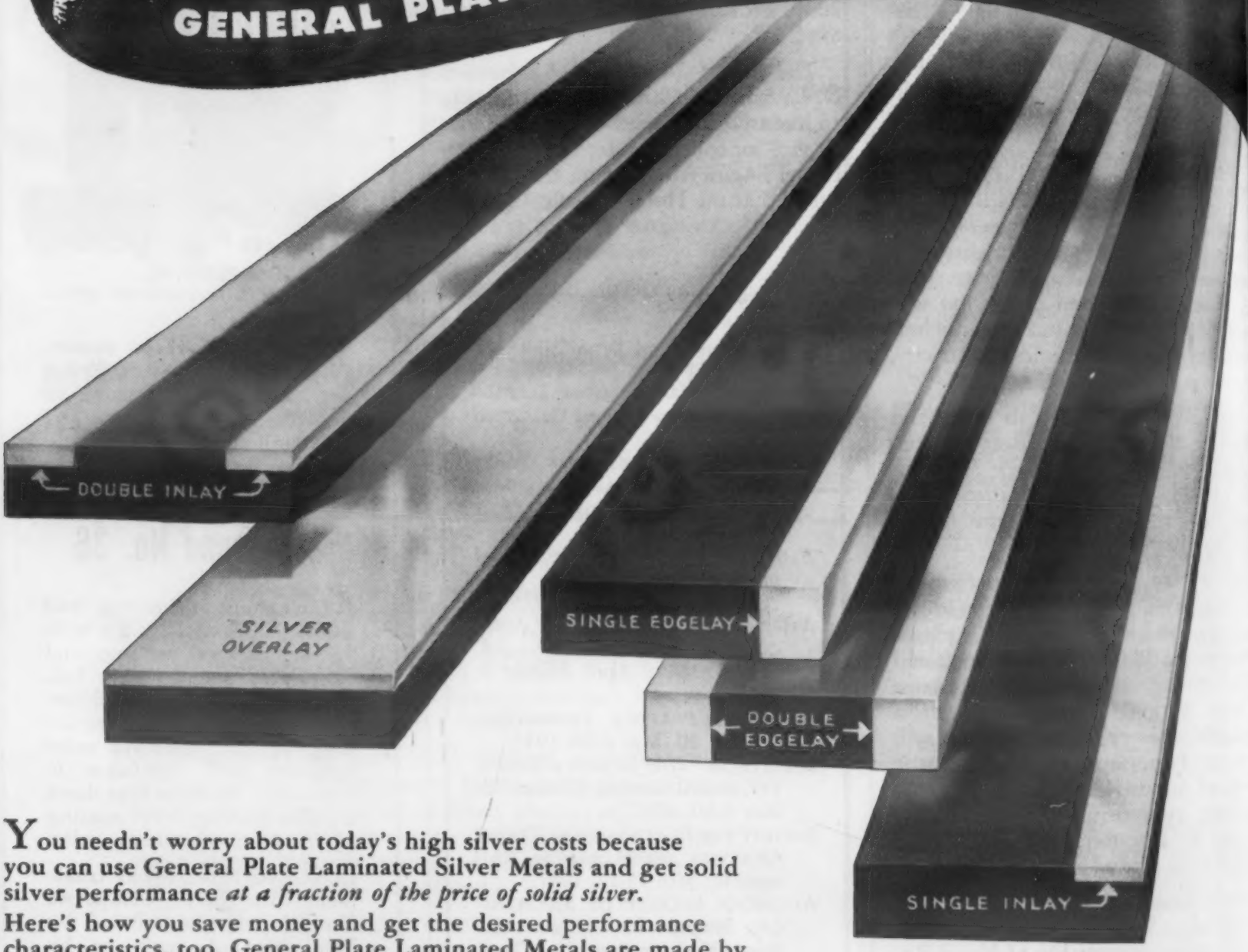

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The Last WORD

by T. C. DU MOND

Mutual Admiration Society

The American Iron & Steel Institute publishes a beautiful house organ called *Steelways*. We are especially fond of it since we number its editors among our fine-tooth-comb readers. We approach *Steelways* in the same fashion. The result is that one or the other of us comments upon something the other said. This leads in turn to the party of the first part making a rebuttal comment. Further comment then . . . but let's stop right now. It's all very friendly, but perhaps a little confusing. Anyway, we like *Steelways*.

Good Use for Old Books

If you need an inspiration to make you clean out your technical library to make room for the countless new publications now becoming available, here it is. There is a desperate need for such books in many countries of the world. The American Book Center for War Devastated Libraries, Inc., makes a fervent plea for any technical book or magazine published during the last 10 years. Books and periodicals they collect are to be shipped to those European and Oriental centers whose libraries were destroyed or depleted during the war. During the past year 700,000 volumes were shipped for that purpose. Send your books and magazines—technical or scholarly only—to the American Book Center, c/o Library of Congress, Washington 25, D. C.

Please Patronize Our Friends

Years ago it was rare indeed that any magazine reached your hands that did not have printed on every advertising page some such plea as: "When writing our advertisers please mention *Super-Dooper Stories*." In recent years we have become somewhat more subtle. Some publications—and some advertisers—devise key addresses by which they trace the source of inquiries. When it comes time to tot the score those publications with the most gold stars get the future business. Far be it from our minds to suggest that you plug M & M when writing to our advertisers. What we would like to ask is that you not use another publication's address when taking action upon inspirations gained in this journal. If this be commercial, make the best of it, for if it were not for the advertising in a magazine little of the valuable material now available would ever see the light of day, for the advertising pages are the beasts of burden which carry the cost of the technical articles.

Editorial Luck

For many years the *Saturday Evening Post* has bragged about the kindly fates which steered it into publishing the right article at the right time. Now we are beginning to learn how they feel. On page 73 of our March issue there began an article on "Printed Electrical Circuits." At just about the same time the popular science writers began describing this development in the newspapers. To make our chop-licking even more tasty, the Bureau of Standards lists this as one of the three most important developments in which they played a part during the war. Number one, of course, was the atom bomb. Could it be that more than luck was involved?

They Fly Through the Pages With the Greatest of Ease

Some scholars much more learned than we have determined that the little letter "e" is the most frequently used letter in the English alphabet. Perhaps that is why some authors overwork the poor character. We know at least one who injects an "e" in every possible place, perhaps on the assumption that it's better to be safe than sorry. We have one special pencil reserved to delete wayward eee's. The chances are that we come out even, for in our zealous fervor we may recklessly yank an "e" out of its natural habitat as often as we let it stay where it doesn't belong.

Some Hope in Prices

The steady rise in price of some n ferrous metals leaves us dizzy, and seems to be having somewhat the so effect on the country in general. though the results were somewhat tile, two companies recently sacrifi their own interests to protest this u healthy trend. Finally, conditio forced them to meet existing pric However, we feel that Kennecott Co per and St. Joseph Lead will be amo the first to reduce prices again wh conditions look ripe. Some produce say the situation is decidedly perilo and that every time metal prices go u one cent, the stock market goes dow two dollars.

Needs Anticipated

Apparently the two features on pla tics in this issue are going to be help ful to a great many people. Reques made on returned questionnaires con tained many questions like thi "What's the price and supply situa tion?" "How do you tell which plasti is which?" "What should the differen plastics be used for?" These are onl a few, but the answers to the thre cited and to many others are listed i these two articles.

Hidden Talent

Sometimes—we feel—technic magazines tend to become too serious stuffy and, upon occasion, downright dull. To avoid such charges against M & M we have started the use o editorial cartoons to bring out pert nent points in certain types of articles The first such cartoons appeared in March and they are continued in the lead article this month. As so often happens, we searched long and futilely for someone to supply such artistic help. Finally, we tried our art depart ment. Right! As so often happens, we found the ideal talent in our own back yard. Lugi, we call her, and we promise her as well as you some good arti cles to work on in the future. Watch for them.

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